# Decision Support System for Promotion Assessment using Analytic Hierarchy Process

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*Abstract*— Promotion Assessment is an important mechanism in every organization to recognize and utilize the talent of the work force efficiently. Exiting approach uses manual process which is highly subjective in nature and hence has high probability of errors. Therefore, automating this process is required to overcome the deficiencies in the manual process. Decision Support System is the most appropriate tool for automation in such kind of scenarios. The proposed system uses criteria based on profession skill and behavioural aspects of staff. This system can further be used to predict those staffs that need training program/ domain technical skill and also predict those staffs that have higher chances of promotion in next assessment. It is based on multi-criteria ranking procedure utilizing Analytic Hierarchy Process (AHP) and weighted score method. The system can be utilized to improve the credibility of the whole assessment process adding transparency to the system. To test the model, the sample is taken from the Defence lab.

*Keywords*—  Decision Support System, Analytic Hierarchy Process, Weighted Score Method, Promotion Assessment

## I.    INTRODUCTION

Human Resource is an asset for any organization and to utilize the talent efficiently, it is necessary to have periodic performance appraisal in the organization. The performance appraisal can be the basis for the promotion assessment process.

According to Moon, C. et al. [1], performance appraisal of candidates in relation to a particular position, is a key task towards managing the human resources of an organization. Supervisors are concerned with performance appraisal judgments and evaluations that they have to make on their subordinates. On the other hand, subordinates are increasingly realizing the importance of performance appraisal since it would very much affect their rewards and future career path. As the world began to shift towards knowledge based capitalism, it reminds all organizations on the importance of maintaining their talented knowledge workers [1].

Performance appraisal is conducted periodically within an organization to survey and review the performance of staff so as to identify the strengths and weaknesses as well as to find out the scope of improvement in the work performance of the Staff. It also gives an objective evaluation of a Staff readiness for promotion and to give the merit for their excellent performance in the organization both in terms of quantity and quality.

Today also in various organizations, the promotion assessment has been done manually leading to high level of subjectivity and risks of man made errors.  A fair and transparent Promotion Assessment mechanism is very important for the future of the organization. For this we need an automated process that takes staff data, operate on it and gives output that helps decision makers make objective decision.

Assessment should be based on the requirement and goals of the organization; for which we need to find the criteria and its priorities for the accomplishment of the process. The use of multiple criteria in the assessment makes the management process difficult to score. Therefore, an appropriate Decision Support System (DSS) is needed for an objective and fair evaluation while having the ease of use. The proposed Decision Support System is designed using Analytic Hierarchy Process (AHP) model and Weighted score method. The aim of this paper is to develop a web-based Decision Support System to support the Defence Lab decision makers in the promotion assessment process. The system would categorize the eligible staff for assessment into 3 classes

'Best Fit', 'Fit' and 'Unfit'. The system will suggest the 'fitness' of the staff for promotion and predict those staff that needs training program/ domain technical skill to improve the performance for the larger good of the organization in general and for themselves in particular.

The Paper will be organized as follows: Section II deals with the related work, section III presents an overview of the Decision support system. In section IV, theoretical aspect of Analytic hierarchy process is presented. In section V, the description of our system framework will be detailed. Finally, section VI presents conclusion summarizing the main results of the paper.

## II. RELATED WORK

Rusli Ahmad and Sopian Bujang in [2] classified performance appraisal into three categories as measuring traits, behaviours or results. They suggested that combination of approaches lead to better implementation of appraisal system.

In [3] Marie Farnandes attempts to compare various techniques for dealing and extracting information from the data.

In [4] author presented various methodologies for improving and evaluating performance for better assessment and decision making in education organization.

Rochmat Taufiq and Aris Sugiharto [5] presented a decision support system for performance appraisal process used for promotion, in which they have taken commitment, management, cooperation and performance as main criteria for assessment and find priorities for the criteria using Analytical Hierarchy Process.

Rusli Ahmad and Nur Azman Ali in [6] discussed a study on the evaluators understanding on the decision making process in the public service performance appraisal system by cognitive processing models. It discusses the steps involved in cognitive process model and presents the study in the context of novice raters.

In [7], the authors proposed a decision support system which uses weightage mathematical model to evaluate the performance appraisal for individual and for department which would ultimately be the basis for the promotion. Technical, managerial and social attributes were chosen for the appraisal process and the weightage for the attributes were assigned by the decision maker.

## III. DECISION SUPPORT SYSTEM

In the early 1970s, Scott-Morton formulates the concept of the first SPK. SPK is a computer-based interactive system that helps to make decisions using data and models to solve unstructured problems (Gorry and Scott-Morton, 1971; Effraim, 2007).

Decision support system is a computer based system that produces a wide range of decision alternatives that assist the

management in dealing with various structured or unstructured problems using data and models [8].

The component of Decision Support System is composed of data management subsystem, model management subsystem and user interface. Turban added another component to the DSS - knowledge based management system (KBMS) [9]. It makes the system more intelligent due to its ability to produce the needed expertise for solving structured or semi-structured problems.

Decision Support System (DSS) couples the intellectual resources of individuals with the capabilities of the computer to improve the quality of decision [9]. According to Sprague and Watson (1996), they define DSS as an interactive computer based system that helps decision-makers use data and models to solve ill-structured, unstructured or semi-structured problems. Making decisions by evaluating the set of alternatives leads to multi-criteria decision making. Different approaches are introduced for multi-criteria decision making such as Analytic Hierarchy Processes (AHP), Elimination Choice Expressing Reality (ELECTRE), Fuzzy method etc.

Before the description of our proposed decision support system, we must need to understand the benefits of having a computerized decision support system which include the following: (1) Maximized the productivity of members of the group, (2) fast computation: allowed decision makers to conduct computation quickly with low costs, thousands of criteria or alternatives could be evaluated in short time, (3) enhanced communication and collaboration, (4) enhanced data management: several decisions contains complex computations; so the resulted data for these can be stored in multiple databases anywhere in the organization and even outside by using such cloud technique, these data includes: text, graphics, sound, and video; from this it is important to transmit data quickly, securely, and transparently by using computers for storing, searching, and transmitting this data, (5) anywhere, anytime support, (6) data warehouse access , (7) improves understanding and increases confidence and assurance in the decisions taken, and finally, (8) Agility and quality support: computers enhanced the overall quality of decision made and helped the organizations to adapt with the changes in the environment to make good decisions quickly and objectively, so they could be able to reengineer processes, changed or replaced some operations, and adds novel solutions [10] [11] [12].

## IV. ANALYTIC HIERARCHY PROCESS

Analytic Hierarchy Process (AHP) is one of the Decision Support Model introduced by Thomas L. Saaty, for dealing with complex decision making. Analytic Hierarchy Process is one of the multi-criteria decision making method that is good in modeling expert opinion in decision support systems. In developing the model, AHP perform pairwise comparisons variables that become a decisive factor in the

decision making process [13]. It takes into account one's preference by putting priority score in the form of matrix criteria, computing the choices and obtaining the percentage of each choice [14]. AHP creates multi-criteria decision making (MCDM) that incorporates both subjective and objective aspects of the decision. The method reduces complex decision problem to a hierarchy of sub-problem and then, synthesizing the results.

The AHP involves the following methodology:
1) Breaking down the goal into a hierarchy of criteria, sub-criteria and alternatives.
2) Developing weights for criteria.
3) Computing pairwise comparison matrix for the list of criteria
4) Normalizing the column of the pairwise comparison.

$$wi = aij / \left( \sum_{k=1}^{n} akj \right). \tag{1}$$

5) Calculating the sum of the value for every $i^{th}$ column

$$a = \sum_{j} aij \tag{2}$$

6) Calculate the priority.

In a pairwise comparison, decision makers would compare two alternatives of one criterion and would signify the preference among the alternatives. Table 1 shows the preference scale by assigning numerical values to different level of priority. In general, in AHP, an n x n pairwise matrix requires n (n-1)/2 entities (Saaty, 1980). The other entities can be readily obtained by using the reciprocity relation $a_{ji} = 1 / a_{ij}$ .

(3)

**Table 1. Preference scale for pairwise comparison**

| Preference Level | Numerical value |
|---|---|
| Equally Preferred | 1 |
| Equally to Moderately Preferred | 2 |
| Moderately Preferred | 3 |
| Moderately to Strongly Preferred | 4 |
| Strongly Preferred | 5 |
| Strongly to Very Strongly Preferred | 6 |
| Very Strongly Preferred | 7 |
| Very Strongly to Extremely Preferred | 8 |
| Extremely Preferred | 9 |

SOURCE: BERNARD W. TAYLOR III, 2004, PAGE 374

## V.    DEFENCE PROMOTION ASSESSMENT PROCESS

### A.  Determinants of Assessment
Performance appraisal is a formal management system that provides for the evaluation of the quality of an individual's performance in an organization [15]. As mentioned by Dessler, G [16], performance appraisal has the means to

evaluate an employee's current and past performance relative to the employee's performance standards. It is a process which involves creating work standards; evaluate employee's actual performance relative to those work standards. Since, it is very important for the organization, it should be done through ample care and fairness, as any ineffectiveness will bring dissatisfaction among the staff. In order to develop a DSS first of all, we need to find out those staffs which are eligible for the current year promotion process. For the Defence lab, staffs are considered eligible only if she/he has completed 5 years of service or has completed 5 years of her/his promotion criteria based on the requirement and need of the organization. According to the lab sample, theoretical study and through a thorough discussion with the superior, following criteria are found out;

1. *ACR:* Every year Staffs are given Annual Confidential Report (ACR) on the scale of 1 to 5 where 5 indicates that Staff was highly rated and 1 indicates that Staff was poorly rated. It is used to assess the annual performance and effectiveness of the staff.
2. *Behaviour Analysis:* The way staff behaves in the organization does not only affect the quality of his work but also affect the productivity of the whole organization. Thus, behaviour analysis becomes an important part of the assessment and a thorough analysis is needed in this. Some of the qualitative analysis as in [5] are  (1) The commitment that includes loyalty, honesty, responsibility, discipline; (2) The Management that consists of the leadership, planning, organizing, directing; (3) The Cooperation that consists of communication, information sharing and the ability for adaptation; (4) the work performance both the quality and the quantity. Though we have considered four classes, we can extend and modify it as per the need of the management.
3. *Knowledge and skills:* The staff's knowledge and skills in the working field is an important aspect for assessment. Our system supports the admin with dynamic and interactive offline graph depicting the distribution of knowledge in various fields.
4. *Number of Projects involved:* Staffs are required to take up Projects for Research Work as part of the organization goal. The number of projects took up by the Staff for Research Work to accomplish the organization goals falls under one of the primitive criteria for assessment.
5.  *Support Services:* Another aspect which is taken into account is the involvement of Staff in the Support Services like in MMC, Administration work, Finance Work, in Technical Library, in Security etc.
6. *Sports:* Sports help Staff to build a drive to contribute to the overall goal, with trying their best to make a big impact while observing the contributions of others. It gives them the spirit to overcome obstacles and continue to move forward despite all odds in their career, making a necessary criterion for assessment to incentivize staff to take part in sports.

7. ***Seniority:*** From experience comes knowledge, this rightly makes seniority as one of the prime evaluator for promotion.

8. ***Retirement:*** A reward for contributing their energy and time for fulfilment of organization goals lead to a basis of giving some weight in the assessment process. In which if the staff is going to be retired with only one year left for the retirement then some preference would be given, which would be predefined and clearly stated.

Based on the mentioned criteria an integrated framework was developed and put into test for the Defence Lab data. DSS needs to evolve over time with changing user needs, organization goals, technologies and problem understanding. This very aspect is well integrated into our system with criteria being dynamic that means with the change of time and need new criteria can be added and older one can be removed. Also, the significance of each criterion can also be changed with the requirement of the organization.

To ensure sensitivity to the system, interview was also made a part of assessment process. For this the semi-structured interview in this study is most appropriate because it provides a great deal of flexibility to interviewees on how to reply the questions. At the same time, interviewers were able to pick up appropriate information by the interviewee [17].

### B. *Performing model analysis*

The next step after analyzing the different criteria for assessment is developing a list of criteria with a pairwise comparison as can be seen in Table 2, then implement normalization on the table of pairwise comparison with equation 1 which can be seen in Table 3, and finally calculate the weight for each criterion as shown in Table 4

**Table 2. Pairwise Comparison Matrix**

| Criteria | ACR | Behavior | Skills | Project | Sports | Support Services | Seniority | Retirement |
|---|---|---|---|---|---|---|---|---|
| ACR | 1 | 3 | 3 | 5 | 9 | 7 | 5 | 5 |
| Behavior | 0.33333333 | 1 | 3 | 5 | 5 | 7 | 3 | 3 |
| Skills | 0.33333333 | 0.33333333 | 1 | 3 | 7 | 7 | 5 | 5 |
| Project | 0.2 | 0.2 | 0.33333333 | 1 | 7 | 9 | 5 | 5 |
| Sports | 0.11111111 | 0.2 | 0.14285714 | 0.14285714 | 1 | 1 | 0.33333333 | 0.33333333 |
| Support Services | 0.14285714 | 0.14285714 | 0.14285714 | 0.11111111 | 1 | 1 | 1 | 1 |
| Seniority | 0.2 | 0.33333333 | 0.2 | 0.2 | 3 | 1 | 1 | 3 |
| Retirement | 0.2 | 0.33333333 | 0.2 | 0.2 | 3 | 1 | 0.33333333 | 1 |

**Table 3. Normalized Matrix of Criteria Values**

| Criteria | ACR | Behavior | Skills | Project | Sports | Support Services | Seniority | Retirement |
|---|---|---|---|---|---|---|---|---|
| ACR | 0.40 | 0.54 | 0.37 | 0.34 | 0.25 | 0.21 | 0.24 | 0.21 |
| Behavior | 0.13 | 0.18 | 0.37 | 0.34 | 0.14 | 0.21 | 0.15 | 0.13 |
| Skills | 0.13 | 0.06 | 0.12 | 0.20 | 0.19 | 0.21 | 0.24 | 0.21 |
| Project | 0.08 | 0.04 | 0.04 | 0.07 | 0.19 | 0.26 | 0.24 | 0.21 |
| Sports | 0.04 | 0.04 | 0.02 | 0.01 | 0.03 | 0.03 | 0.02 | 0.01 |
| Support Services | 0.06 | 0.03 | 0.02 | 0.01 | 0.03 | 0.03 | 0.05 | 0.04 |
| Seniority | 0.08 | 0.06 | 0.02 | 0.01 | 0.08 | 0.03 | 0.05 | 0.13 |
| Retirement | 0.08 | 0.06 | 0.02 | 0.01 | 0.08 | 0.03 | 0.02 | 0.04 |

**Table 4. Weight of Criteria Values**

| Criteria | ACR | Behavior | Skills | Project | Sports | Support Services | Seniority | Retirement | Weightage | Priority |
|---|---|---|---|---|---|---|---|---|---|---|
| ACR | 1 | 3 | 3 | 5 | 9 | 7 | 5 | 5 | 2.57 | 0.32 |
| Behavior | 0.33 | 1 | 3 | 5 | 5 | 7 | 3 | 3 | 1.65 | 0.21 |
| Skills | 0.33 | 0.33 | 1 | 3 | 7 | 7 | 5 | 5 | 1.38 | 0.17 |
| Project | 0.20 | 0.20 | 0.33 | 1 | 7 | 9 | 5 | 5 | 1.14 | 0.14 |
| Sports | 0.11 | 0.20 | 0.14 | 0.14 | 1 | 1 | 0.33 | 0.33 | 0.20 | 0.02 |
| Support Services | 0.14 | 0.14 | 0.14 | 0.11 | 1 | 1 | 1 | 1 | 0.26 | 0.03 |
| Seniority | 0.20 | 0.33 | 0.20 | 0.20 | 3 | 1 | 1 | 3 | 0.47 | 0.06 |
| Retirement | 0.20 | 0.33 | 0.20 | 0.20 | 3 | 1 | 0.33 | 1 | 0.35 | 0.04 |

### C. *Calculationing marks of staff for internal assessment*

After calculating priority of the criteria, scores of staff need to be calculated. Weighted Score method is then used to find the assessment scores. The result is shown in figure1 for the eligible staff.

**Assessment Details for the Current Year**

| S.NO. | DOSSIER NUMBER | ACR | QUALIFICATION WEIGHTABLE | BEHAVIORAL WEIGHTABLE | SPORTS WEIGHT | PROJECT WEIGHTAGE | RETIREMENT WEIGHTAGE | SUPPORT SERVICE WEIGHTAGE | SENIORITY WEIGHTAGE | YEARS | MARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 31973 | 94 | 60 | 100 | 100 | 20 | 0 | 100 | 83 | 2018 | 74 |
| 2 | 34030 | 88 | 80 | 85 | 100 | 50 | 0 | 100 | 8 | 2018 | 72 |
| 3 | 33781 | 88 | 70 | 90 | 100 | 30 | 0 | 100 | 67 | 2018 | 72 |
| 4 | 33741 | 94 | 80 | 100 | 100 | 10 | 0 | 100 | 17 | 2018 | 72 |
| 5 | 33748 | 88 | 78 | 90 | 0 | 30 | 0 | 100 | 50 | 2018 | 71 |
| 6 | 33749 | 85 | 80 | 100 | 0 | 10 | 0 | 100 | 58 | 2018 | 70 |
| 7 | 33747 | 88 | 65 | 85 | 100 | 20 | 0 | 100 | 42 | 2018 | 67 |
| 8 | 32020 | 80 | 70 | 80 | 0 | 40 | 0 | 0 | 14 | 2018 | 61 |
| 9 | 21288 | 72 | 70 | 80 | 100 | 10 | 0 | 0 | 100 | 2018 | 61 |
| 10 | 31866 | 80 | 70 | 85 | 0 | 10 | 0 | 0 | 43 | 2018 | 59 |

Figure 1. Scores of staff in Internal Assessment

### D. *Calculate total scores of the staff*

Giving equal weight to both the output from the system and interview, we tried to add sensitivity to the whole process. The final scores of all the eligible staff is shown in figure 2.

**Total Scores of the staff**

| S.NO. | DOSSIER NUMBER | MARKS | INTERVIEW | TOTAL MARKS |
|---|---|---|---|---|
| 1 | 33781 | 72 | 95 | 84 |
| 2 | 21288 | 61 | 100 | 81 |
| 3 | 34030 | 72 | 88 | 80 |
| 4 | 33749 | 70 | 87 | 79 |
| 5 | 33741 | 72 | 78 | 75 |
| 6 | 32020 | 61 | 86 | 74 |
| 7 | 31973 | 74 | 55 | 65 |
| 8 | 32143 | 39 | 85 | 62 |
| 9 | 33748 | 71 | 45 | 58 |
| 10 | 33747 | 67 | 46 | 57 |

Figure 2. Total Scores of staff in Promotion Assessment

### E. Categorizing Staff for the promotion decision

Once the final scores have been calculated, the scores will be automatically processed by the DSS based on the predetermined requirement of each designation and for each designation, it would classify eligible staff into 'best fit', 'fit' and 'unfit'.

The result of the final assessment for a specific designation is as shown below where the predetermined requirement for an eligible staff for best fit is 50% and the number of eligible staff for a particular designation is 8. The result of best fit staff is in figure 3, for fit staff in figure 4 and for unfit staff in figure 5:

**Best Fit 'TO-A' Details for the current year**

| SNO | DOSSIER NUMBER | NAME |
|---|---|---|
| 1 | 33781 | Shri DILIP KUMAR SHAH |
| 2 | 34030 | Shri SUBODH KUMAR |
| 3 | 33749 | Shri RAVI SHANKAR SHUKLA |
| 4 | 33741 | Shri RAKESH KUMAR |

Figure 3. Best Fit 'TO-A' Staff

**Fit 'TO-A' Details for the current year**

| SNO | DOSSIER NUMBER | NAME |
|---|---|---|
| 1 | 31973 | Shri VIDYA SHANKAR |
| 2 | 32143 | Shri AMIT ANAND |

Figure 4. Fit 'TO-A' Staff

**Unfit 'TO-A' Details for the current year**

| SNO | DOSSIER NUMBER | NAME |
|---|---|---|
| 1 | 33748 | Shri CHANDRESH SRIVASTAVA |
| 2 | 33747 | Shri BRIJ KISHORE |

Figure 5. Unfit 'TO-A' Staff

## VI. CONCLUSION

In this paper, we proposed a Decision Support System model based on Analytic Hierarchy Process and weighted score method. The system automates the promotion assessment process to obtain an unbiased result. The most prominent feature of this system is flexibility that is it can accommodate changes as per the need of the organization. The outcomes obtained after implementation of this system on the defence data are more efficient and appropriate as compared to manually obtained. It reduces time, unnecessary documentation and also promotes transparency and accountability in the promotion process. The results and conclusions suggest that this system can be utilized in any workplace.

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