A Study On Election Of Personnel Based On Performance Measurement By Using Analytic Network Process (ANP)

Semra BORAN[†] **Kerim GÖZTEPE**[††] **Elif YAVUZ** [††]

[†]Engineering Dept, Sakarya University
[††]Institute of Science and Technology, Sakarya University, Sakarya; Turkey

Summary
It is an important problem of an organization to select the most suitable personnel among the candidates for the vacant positions. Selecting the wrong candidate negatively affects the performance and competitive power of organization. The personnel selection is made mainly upon their performances thus far. There are many methods to measure the performances of personnel. One of the weaknesses of these traditional methods is that they don't consider the relationship between the criteria used for evaluation. There are, however, relationships, interrelationships and feedbacks between them.

In this paper, Analytical Network Process (ANP) method which can be used for selecting the most suitable personnel is discussed and a case study is presented.

Key words:
Personnel Selection, Analytical Network Process (ANP), Performance Measurement.

1. Introduction

For organizations, competing and surviving in markets mainly depends on having best fitting personnel, especially at middle and senior level. Assignment of the suitable personnel in organizations for vacant positions is made according to the evaluation results of the performances. There are many traditional performance evaluation methods that have many weaknesses. One of them is the difficulty in measuring subjective criteria such as attitude, loyalty and personality. The other weaknesses is, they don't evaluate the relationship between the criteria. In recent days, the multi criteria decision making techniques such as Analytic Hierarchic Process (AHP)is used that considers both of subjective and objective criteria. AHP handles the criteria factors in hierarchical order, developed by Saaty [1]. The method is suitable for selection among alternative personnel. Labib et al.[2] suggest a selection of personnel process that employs AHP with four stages. Lazarevic's [3] model consists of an AHP of three levels. In another study, AHP is used for the selection of auditor [4].

In the AHP, it is possible to evaluate the subjective and objective criteria simultaneously. But, not all the interrelationship between criteria is considered in AHP. Analytic Network Process (ANP) is the more developed version of AHP, designed by Satty [1]. ANP overcomes the weaknesses of other methods and AHP.. ANP is a multi attribute decision making method used as a alternative evalution method as regards the objective and subjective factors simultaneously and can consider the relationship between the factors. ANP was used for many selection problems in very different cases. For instance, selection of logistics service provider [5], [6] supplier [7],[8],[9], project [10] and university [11] etc.

2. Personnel Performance Evaluation

In determining individual performance, various evaluation or measuring methods are used for various purposes. Performance evaluation results are used in determining the salary, promotion and the best fitting employee for vacant positions.

3. Analytic Network Process (ANP) Method

ANP is an improved form of AHP. AHP model contains hierarchical relationship between overall goal, criteria, sub criteria and alternatives. But the problems don't always show hierarchical structure. In such a case, ANP structures the problem as network instead of hierarchical modelling.

However in ANP, criteria in the lower level may provide feedback to the criteria in the higher level, and the interdependence among the criteria in the same level is permitted [12]. Another difference between AHP and ANP in calculation process is that a new concept "supermatrix" is introduced in ANP [12]. The application steps of ANP are as fallows [13],[14]

Manuscript received April 5, 2008
Manuscript revised April 20, 2008

3.1. Forming the Network Structure

Firstly, criteria, sub criteria and alternatives are defined. Then, the clusters of elements are determined. Network is formed based on relationship among clusters and within elements in each cluster. There are few different relationships that have effects. Direct effect may be considered as a regular dependency in a standard hierarchy. Indirect effect dependency of which is not direct and must flow through another criteria or alternative. The another effect is the self-interaction one. Last is interdependencies among criteria which form a mutual effect.

3.2. Forming Pairwise Comparison Matrices and Obtaining Priority Vector

Pair wise comparisons are performed on the elements within the clusters as they influence each cluster and on those that it influences, with respect to that criterion. The pairwise comparisons are made with respect to a criterion or subcriterion of the control hierarchy [13]. Thus, importance weight of factors are determined. In pairwise comparison, decision makers compare two elements. Then, they determine the contribution of factors to the result [14]. In ANP, like AHP, it is formed pairwise comparison matrices with use 1-9 scale of relative importance proposed by Saaty [15]. 1-9 scale of relative importance is given at Table 1.

Table 1: Scale of Relative Importance (Adapted from Saaty [1] and Vargas [17])

Intensity Of Importance	***Definition***
1	Equal importance
3	Moderate importance
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate value between adjacent scale values

The values of pairwise comparisons are allocated in comparison matrix and local priority vector is obtained from eigenvector which is calculated from this equation: $Aw = \lambda_{enb} w$. In this equation, A,w and λ_{enb} stands for the pairwise comparison matrix, eigenvector and eigenvalue, respectively.

Saaty has proposed normalization algorithm for approximate solution for w [1].

The matrix which shows the comparison between factors is obtained as follows:

$$A = \lfloor a_{ij} \rfloor_{nxn} \qquad i=1,......,n\ j=1,......n \qquad (1)$$

Significance distribution of factors as percentage is obtained as follows:

$$B_i = \lfloor b_{ij} \rfloor_{nx1} \qquad i=1,........,n \qquad (2)$$

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \qquad (3)$$

$$C = \lfloor b_{ij} \rfloor_{nxn} \qquad i=1,......n\ j=1,.......n \qquad (4)$$

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \qquad W = [w_i]_{nx1} \qquad (5)$$

3.3.Forming Supermatrix and Limit Super Matrix

The overall structure of supermatrix is similar to markov chain process. [15];[16]. To obtain global priority in a system that has interdependant effects, all local priority vectors are allocated to the relevant columns of supermatrix. Consequently, supermatrix is a limited matrix and every part of it shows the relationship between two elements in the system . The long term relative impacts of the elements to each other are obtained by raising the supermatrix power. To equalize the importance weights, power of the matrix is raised to the 2k +1, where k is an arbitrary large number. The new matrix is called limited supermatrix [15]. The consistency of elements comparisons are calculated as follows:

$$D = \lfloor a_{ij} \rfloor_{nxn} x [w_i]_{nx1} = [d_i]_{nx1} \qquad (6)$$

$$E_i = \frac{d_i}{w_i} \qquad i=1,......,n$$

(7)

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \qquad (8)$$

$$CI = \frac{\lambda - n}{n-1} \qquad (9)$$

$$CR = \frac{CI}{RI} \qquad (10)$$

In the equations above, CI, RI and CR represent consistency indicator, random indicator and consistency ratio, respectively. Consistency of pairwise matrix is checked by consistency index (CI). For accepted consistency, CI must be smaller than 0.10 [1].

3.4. Selection of The Best Alternative

It is able to determine importance weights of alternatives, factors and sub factors from limited supermatrix. The highest importance weight shows the best alternative.

4. Selection Of Personnel via ANP Method

4.1. Forming the Network Structure

Performance criteria and sub criteria that are used selection of suitable personnel are determined by experts. In our proposed network model, the three main criteria are management, decision making and necessary requirements. There are three, two and six sub criteria in management, decision making and necessary requirements, respectively. In this case study, three candidates are chosen as alternatives. The main criteria together with subcriteria form a cluster. Therefore, a total of four clusters were made; three for criteria and one for alternatives.

Cluster of Candidates

The cluster consists of candidates that will be selected for an important position. The candidates are working in the organization. In the proposed model three candidates are labelled C1,C2 and C3.

Cluster of Management

Management is first main factor. Management is a vital function in an organization. The function of management is to get the best return on resources efficiently. That's why the candidate manager has to know how to lead and motivate employees. We defined three sub criteria for this cluster, namely: M1,M2 and M3.

Planning and Organization (M1): Process planning and organization is a process of helping an organization to envision what it hopes to accomplish in the future. Plans identify and display opportunities that affect the organization's ability to achieve its vision; and set forth the resources and activities to enable the achievement of the goals and objectives. A manager has to have planning ability. Managerial candidates should be able to organize work, time, labor and related issues to achieve organizations's goal.

Administrative Orientation (M2): It is important for a manager to adopt to new situations. Elected manager should learn his tasks as soon as possible. Organizations will loose time, market share and money in case managers can't adopt soon.

Leadership (M3): A leader is a person who impresses other people to accomplish objectives and leads the organization towards targeted objectives. A leader makes use of his/her ability to carry out the process. All the candidates were tested by decision makers in terms of their leadership ability.

Cluster of Decision Making

Second main factor is decision making ability. Decision making is one of the key factors for organizations. Organizations need the right kind of managers to survive. Manager should have the courage of taking some critical decision at times of crises. We defined two sub criteria in decision making cluster: Risk evaluation (DM1) and initiative (DM2).

Risk Evaluation (DM1): Global economy poses many new risks. A modern manager should be able to evaluate all of them and make decision accordingly.

Initiative (DM2): Modern manager should have initiate power especially at critical times.

Cluster of Necessary Requirements

Last main factor is requirements. The cluster of necessary requirements consists of other evaluation of performance criteria like education and training, behavioral flexibility, global understanding, reward/punishment, teamwork.

Education and training (NR1): Manager should have sufficent fundamental education level. Moreover, he/she has to get all the training necessary to carry out his/her job a global environment.

Behavioral Flexibility (NR2): Manager should understand his/her employees and have a sound communication with them.

Global Understanding (NR3): Much than before, organizations are under the impact of global events. So the modern manager should have skill to evaluate organization's problems from the global perspective.

Reward/Punishment (NR4): Reward and punishment are like to faces of a medal. Both is used as instrument for a fair motivating management. Managers can be rewarded by their organization or other ones or take bad score.

Teamwork (NR5): In a modern, horizontal organization teamwork is necessary especially to achieve specific goals. Manager has to be member of team that is called project team, productivitiy team, improving team etc.

International Experience (NR6): For candidate, knowledge gained from international experience can affect his/her background in a positively way. Candidate who has more overseas duties and experiences takes advantage.

In this model, the relationship between clusters and criteria are identified even they aren't hierarchical. The links between elements affect each other. The main objective which is to select the best fitting candidate placed on the topmost level of the model. Second level consists of the main three criteria that affects the selection of the best fitting candidate. The eleven sub criteria is at the lower levels. There are three candidates which are evaluated at the lowest level (Figure 1).

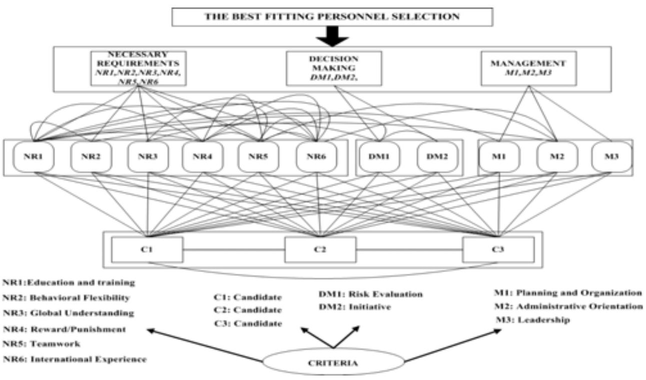

Figure 1: The Network Structure of the Proposed Model

The relationship between elements is given in Table 2.

Table 2 . The Relationship Between Elements

Affected Criteria	Affecting Criteria
C1	C2,C3,M1,M2,M3,DM1,DM2,NR1,NR2, NR3,NR4,NR5,NR6
C2	C1,C3,M1,M2,M3,DM1,DM2,NR1,NR2, NR3,NR4,NR5,NR6
C3	C1,C2,M1,M2,M3,DM1,DM2,NR1,NR2, NR3,NR4,NR5,NR6
M1	C1,C2,C3
M2	C1,C2,C3
M3	C1,C2,C3
DM1	NR1
DM2	DM1
NR1	M1,NR2,NR4,NR5
NR2	M2
NR3	DM1,NR6
NR4	NR1,NR5,NR6
NR5	NR1,NR4,NR6
NR6	NR1,NR4,NR5

4.2. Forming Pairwise Matrix

A relationship exists among clusters and the elements within the clusters. For example, there is interrelationship between necessary requirement cluster and decision making one. Similarly, the subcriteria NR1 and NR4 have an interrelationship. In decision making cluster, DM1 affects DM2 but DM2 doesn't have an impact on DM1. The clusters affect themselves with the exception of Management cluster (Figure 2).

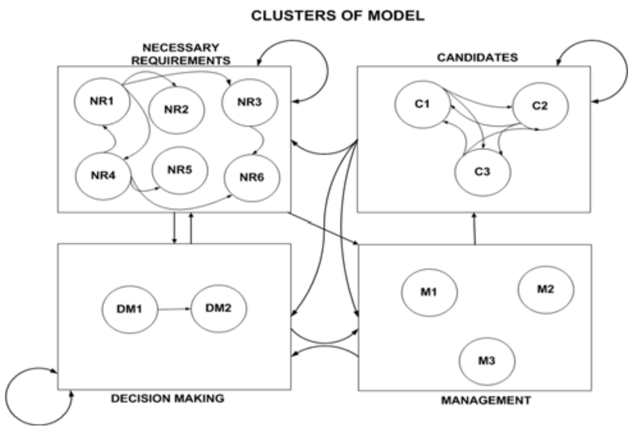

Figure 2:Clusters of Model

The pairwise comparisons based on the relationships mentioned above were made among elements by using 1-9 scale. Then, the pairwise comparisons were allocated to pairwise comparison matrix and the eigenvalues were calculated. The results were obtained with the help of Super decision software program. A pair wise comparisons according to "NR1" in necessary requirements cluster is given in matrix at Table 3. Its consistency Index of is 0.0 and less than 0,10.

Table 3. An example of pair-wise comparison matrix

	NR2	NR4	NR5	weight
NR2	1	0,3155	1	0,1934
NR4	3,1696	1	3,1698	0,6131
NR5	1	0,3154	1	0,1934

4.3. Forming Super matrix and limit supermatrix

Initial supermatrix (unweighted matrix) is formed by priority vectors which are calculated from pairwise comparison matrixes. In initial supermatrix, the cells get two values: priority vectors and zero. In matrix, priority vectors exists in cells where interdependent factors intersect. The zero valued cells consists of non-relationship factors. The supermatrix of the proposed model is given in Table 4.

Table 4 The Supermatrix of the Proposed Model

	Candidates			Management			Decision Making		Necessary Requirements					
	C1	C2	C3	M1	M2	M3	DM1	DM2	NR1	NR2	NR3	NR4	NR5	NR6
C1	0	0,522	0,208	0,276	0,144	0,202	0	0	0	0	0	0	0	0
C2	0,875	0	0,792	0,482	0,729	0,602	0	0	0	0	0	0	0	0
C3	0,125	0,477	0,000	0,241	0,128	0,195	0	0	0	0	0	0	0	0
M1	0,207	0,178	0,281	0	0	0	0	0	1	0	0	0	0	0
M2	0,130	0,112	0,072	0	0	0	0	0	0	1	0	0	0	0
M3	0,663	0,709	0,647	0	0	0	0	0	0	0	0	0	0	0
DM1	0,705	0,795	0,688	0	0	0	0	1	0	0	1	0	0	0
DM2	0,294	0,204	0,313	0	0	0	0	0	0	0	0	0	0	0
NR1	0,049	0,326	0,046	0	0	0	1	0	0	0	0	0,203	0,126	0,196
NR2	0,035	0,193	0,100	0	0	0	0	0	0,193	0	0	0	0	0
NR3	0,072	0,192	0,098	0	0	0	0	0	0	0	0	0	0	0
NR4	0,496	0,148	0,426	0	0	0	0	0	0,613	0	0	0	0,349	0,6
NR5	0,237	0,069	0,241	0	0,247	0	0	0	0,193	0	0	0,24	0	0,196
NR6	0,108	0,068	0,090	0	0,753	0	0	0	0	0	1	0,556	0,523	0

The weighted matrix is obtained through normalizing of initial matrix which is also called weighted supermatrix (Table 5).

Table 5: The Weighted Supermatrix of the Proposed Model

	Candidates			Management			Decision Making		Necessary requirements					
	C1	C2	C3	M1	M2	M3	DM1	DM2	NR1	NR2	NR3	NR4	NR5	NR6
C1	0	0,263	0,105	0,276	0,108	0,202	0	0	0	0	0	0	0	0
C2	0,441	0	0,399	0,482	0,549	0,602	0	0	0	0	0	0	0	0
C3	0,063	0,241	0	0,241	0,096	0,195	0	0	0	0	0	0	0	0
M1	0,021	0,018	0,028	0	0	0	0	0	0,331	0	0	0	0	0
M2	0,013	0,011	0,007	0	0	0	0	0	0	1	0	0	0	0
M3	0,066	0,070	0,064	0	0	0	0	0	0	0	0	0	0	0
DM1	0,074	0,083	0,072	0	0	0	0	1	0	0	0,169	0	0	0
DM2	0,031	0,021	0,033	0	0	0	0	0	0	0	0	0	0	0
NR1	0,014	0,096	0,013	0	0	0	1	0	0	0	0	0,203	0,127	0,196
NR2	0,010	0,057	0,029	0	0	0	0	0	0,129	0	0	0	0	0
NR3	0,021	0,056	0,029	0	0	0	0	0	0	0	0	0	0	0
NR4	0,145	0,044	0,125	0	0	0	0	0	0,410	0	0	0	0,350	0,607
NR5	0,070	0,020	0,070	0	0,061	0	0	0	0,129	0	0	0,240	0	0,196
NR6	0,032	0,020	0,026	0	0,186	0	0	0	0	0	0,831	0,557	0,524	0

Limit super matrix is also generated from super matrix and priority values are found from the formulation Limit supermatrix shows the importance weights of sub factors, factors and alternatives.(Table 6).

Table 6. The Limit Supermatrix of Proposed Model

	Candidates			Management			Decision Making		Necessary requirements					
	C1	C2	C3	M1	M2	M3	DM1	DM2	NR1	NR2	NR3	NR4	NR5	NR6
C1	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041	0,041
C2	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075	0,075
C3	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036	0,036
M1	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047	0,047
M2	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025
M3	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010
DM1	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,017
DM2	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004
NR1	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133	0,133
NR2	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,023
NR3	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006
NR4	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242	0,242
NR5	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126
NR6	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214	0,214

We obtained score of candidates, which are represented by raw values, from limit supermatrix table. To get normal values, raw values are summed up and every row in raw column is divided by the sum. To obtain ideal values, every value in raw values column is divided by the greatest value of the column.

It can be clearly seen that C2 has the best score and can be said that C2 is most suitable candidate(Table 7).

Table 7: The Results of the Proposed Model

Name	Ideals	Normals	Raw
C1	0.550304	0.270443	0.041382
C2	1.000.000	0.491442	0.075199
C3	0.484524	0.238116	0.036436

5. Conclusion

In this study, ANP model was developed for personnel selection. The model has many advantages. One of the advantages is that it allows both subjective and objective criteria in decision making process. The biggest advantage of this model is that it concerns dependencies and interdependencies among criteria, sub criteria and alternatives. Moreover, the model is flexible in that new criteria, sub criteria and candidates are easily added to it. This study showed that ANP method can give best result if personnel selection model is well prepared to meet our needs.

References

[1] Saaty, T.L.,1980, “The Analytic Hierarchy Process”, McGraw-Hill, New York

[2]Labib,A.W., Williams G.B: and O’Connar, R.F., 1998. “An İntelligent Maintenance Model (System): An Application of The Analytic Hierarchy Process And A Fuzzy Rule-Based Controller”, Journal of Operational Research Society. v49. 745-757.

[3]Lazarevic S., 2001, “Personnel Selection Fuzzy Model”. International Transactions in Operational Research. v8. 89-105.

[4]Seol I., Sarkis J., 2005, “A Multi-attribute model for internal auditor selection”, Managerial Auditing Journal, vol.20, 876-892.

[5]Jharkharia, S., Shankar R., 2007, “Selection of Logistics Service Provider: An Analytic Network Process (ANP) Approach” , Omega Vol.35, 274-289.

[6]Meade, L.M., Sarkis, J.,1998, "Strategic Analysis of Logistics and Supply Chain Management Systems Using The Analytical Network Process" Transpn Res.-E (Logistics and Transpn Rev.), Vol. 34, No. 3, 201-215

[7]Lee,E.K., Ha, S., Kim S.K., 2001, "Supplier Selection and Management System Considering Relationship Supply Chain Management", Engineering Management, IEEE Transaction, pp.307-318.

[8]Min, H., 1994, "International Supplier Selection: A Multi-Attribute Utility Approach." International Journal of Physical Distribution and Logistics Management 24, 24-33

[9]Barbarosoglu, G., Yazgac, T., 1997, "An Application of The AHP To The Supplier Selection Problem." Production and Inventory Management Journal, 15–21

[10]Meade, L.M., Presley, A.,2002, "R&D Project selection using the ANP", Engineering Management, IEEE Transactions on, vol 49, 59-66.

[11]Poonikom, K, O'Brien C., Chansa-ngavej C., 2004, "An application of the ANP for university selection decisions", Science Asia, 30, 317-326

[12]Liang C., Li Q., "Enterprise information system project selection with regard to BOCR " International Journal of Project Management, 2007.

[13]Saaty, T.L., 1999, "Fundamentals of the Analytic Network Process" ISAHP, Kobe, August, 12-14.

[14]Saaty, T.L., 2001, "Making with Dependence and Feedback", 2nd edi., RWS Publication.

[15]Saaty,T.L., 1996, "Decision Making with Dependence and Feedback:The Analytic Network Process", Pittsburgh,PA:RWS Publications.

[16]Saaty, T.L.,2005, "Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks", RWS Publications, Pittsburg, PA, USA.

[17]Saaty T.L. and Vargas L.G., 2006 "Decision Making with the Analytic Network Process", Springer.

Semra Boran received her B.S. degree in Industrial Engineering from ITU Sakarya Engineering Faculty in 1983 and M.S. degree in Industrial Engineering in 1987 from Istanbul Technical University (İTÜ), Turkey. Attained her Ph.d. in Industrial Engineering in Yıldız Technical University, İstanbul, Turkey in 1996. Had been a Teaching Assistant at department of Industrial Engineering, Kocaeli University between 1986 and 1995. Presently, she is an assistant professor of the Industrial Engineering in Sakarya University. During 1998-2000, she had been in Clemson University, USA as visiting scholar. Her areas of study include statistical process control, quality management, experiment of design. She also is a member of Operational Resarch Society of Turkey and Chamber of Mechanical Engineers.

Kerim Goztepe received the B.S.degree in System Engineering from Turkish Military Academy in 1998. While educating in Infantry school (1999), he was joined war simulation group and attended in establishment of JANUS system.He followed JTLS (Joint Theater Level Simulation) courses in 2001.He was accepted in Marmara University and received M.S. degree in Engineering Management in 2003.He started doctoral education in Industrial Engineering, Institute of Science and Technology at Sakarya University in 2006.He is interested in adapting Open Source Systems for Army.He is in Army as captain now.

Elif Yavuz received her B.S. and M.S. Degrees in Industrial Engineering from Sakarya University in 2003 and 2005 respectively. She is currently a Ph.d student in Sakarya University Institute of Science and Technology. Beginning from 2004 she is serving as a Lecturer at Adapazari Vocational School (Distance Education).