Optimization of The Turkish Air Force Personnel-Course Assignment Process

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Outline

- Introduction
- Literature review
- Methodology
- Analysis
- Conclusion

Introduction

- *Motivation:*
  - Multi criteria problem from the TURAF
  - Better utilization of assignments and selection process
  - Develop a value model and a matching algorithm

Introduction

- *Research Question:*

Is there any way to build a robust, effective and efficient decision support model (DSM) which provides *maximum utilization* of the course/education planning system for the TURAF; includes the *cost* of a course; and *reduces the number of hours worked* by officials when accomplishing their tasks?

Introduction

- *Decision Makers:*
  - Air Force Commander
  - Chief of Staff

- *Subject Matter of Experts (SME):*
  - The officials in the Individual Education Branch

Introduction

- *Scope:*
  - Officer's course/education planning
  - Deterministic
  - Turkish Air Force (TURAF) Instructions and SME's opinions
  - Notional Value Model

Introduction

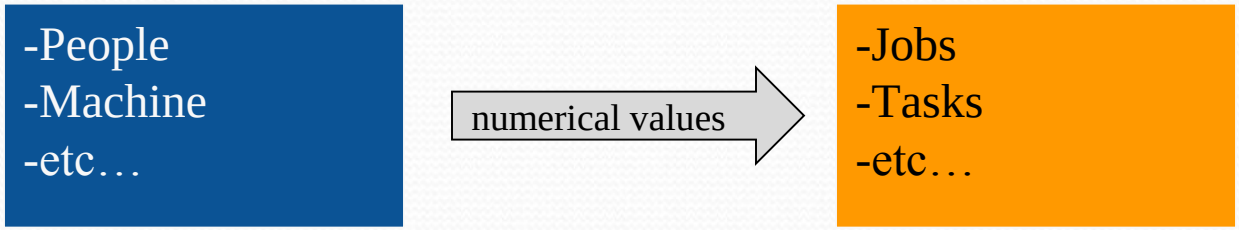
- *Assumptions:*
  - For at least one course, there is an intersection among the personnel's course domain, which is a all set of courses for a given personnel, in a course pool.
  - Personnel can be eligible for more than one course at a time.
  - Exceptional situations (classified courses, special branches, etc.) are excluded from the scope of this research.

Introduction

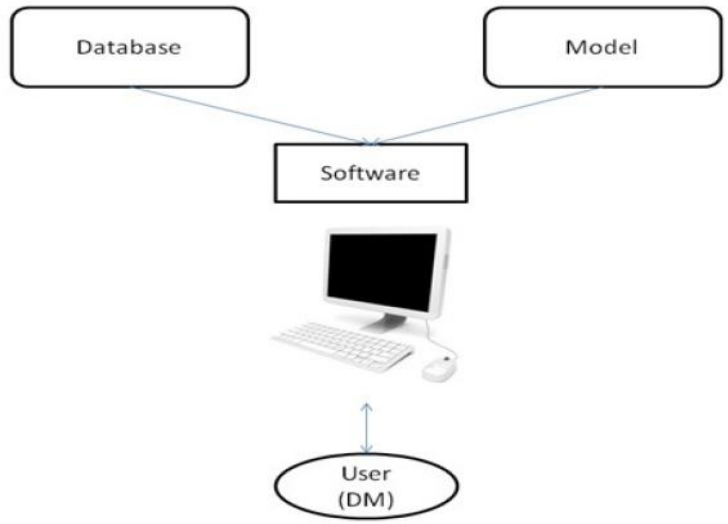
- *Assumptions:*
  - Because of the privacy of the personnel data, random numbers are used instead of actual data. The random data is well suited and there is no need to validate the data.
  - The random data is also used for the cost of a course. The cost is same for all personnel who can be assigned to given course.
  - Any course may be canceled from the assignment pool.

Literature Review

- Assignment matching problem



- Decision Support Models

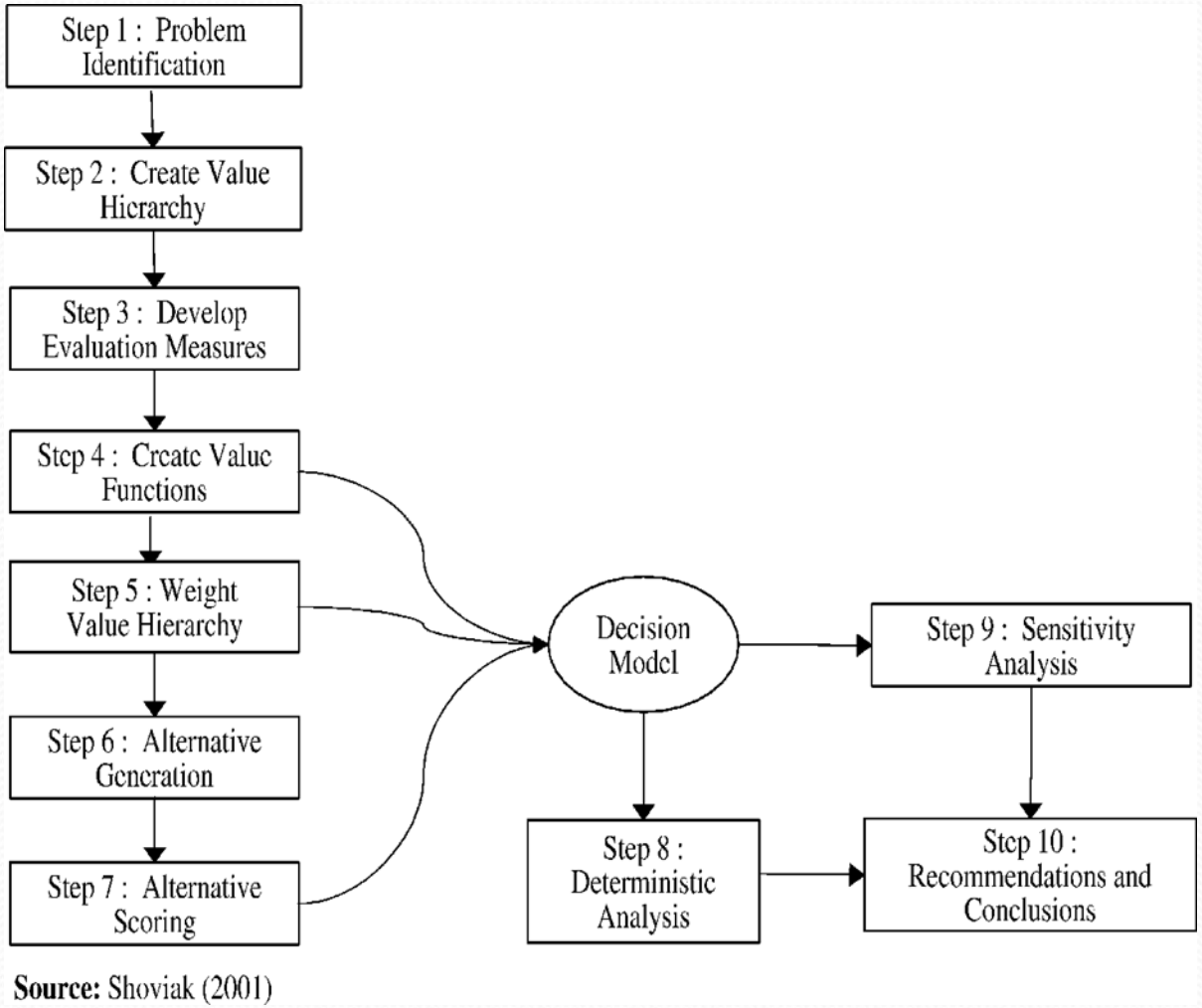


Literature Review

- Multi Criteria Decision Analysis (MCDA) Methods
  - Goal Programming
  - Weighted Summation
  - Multi-Attribute Utility Theory
  - ELECTRE Method
  - PROMETHEE Method
  - Analytic Hierarchy Process (AHP)
  - Value Focused Thinking (VFT)

Literature Review

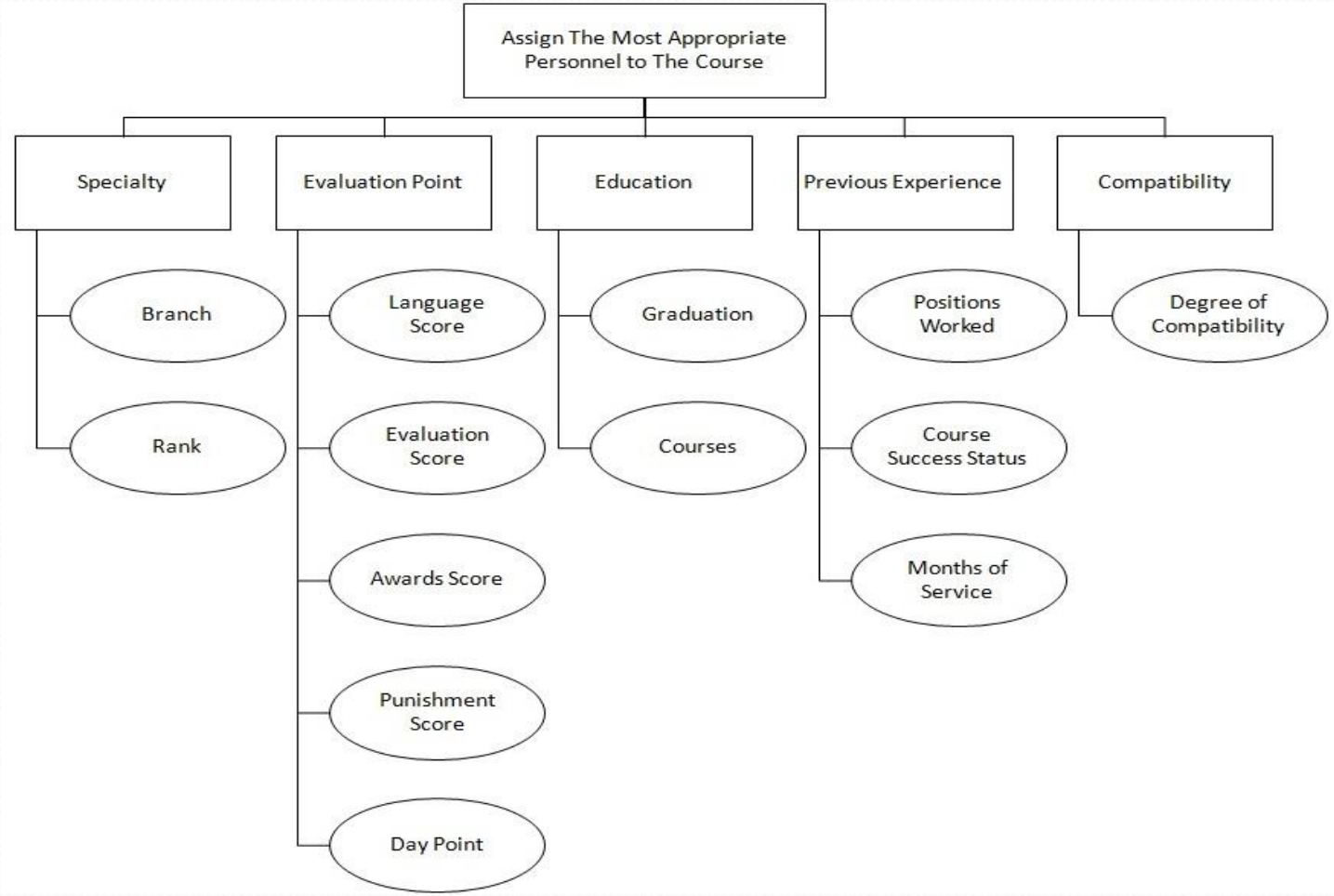
- *VFT:*



Source: Shoviak (2001)

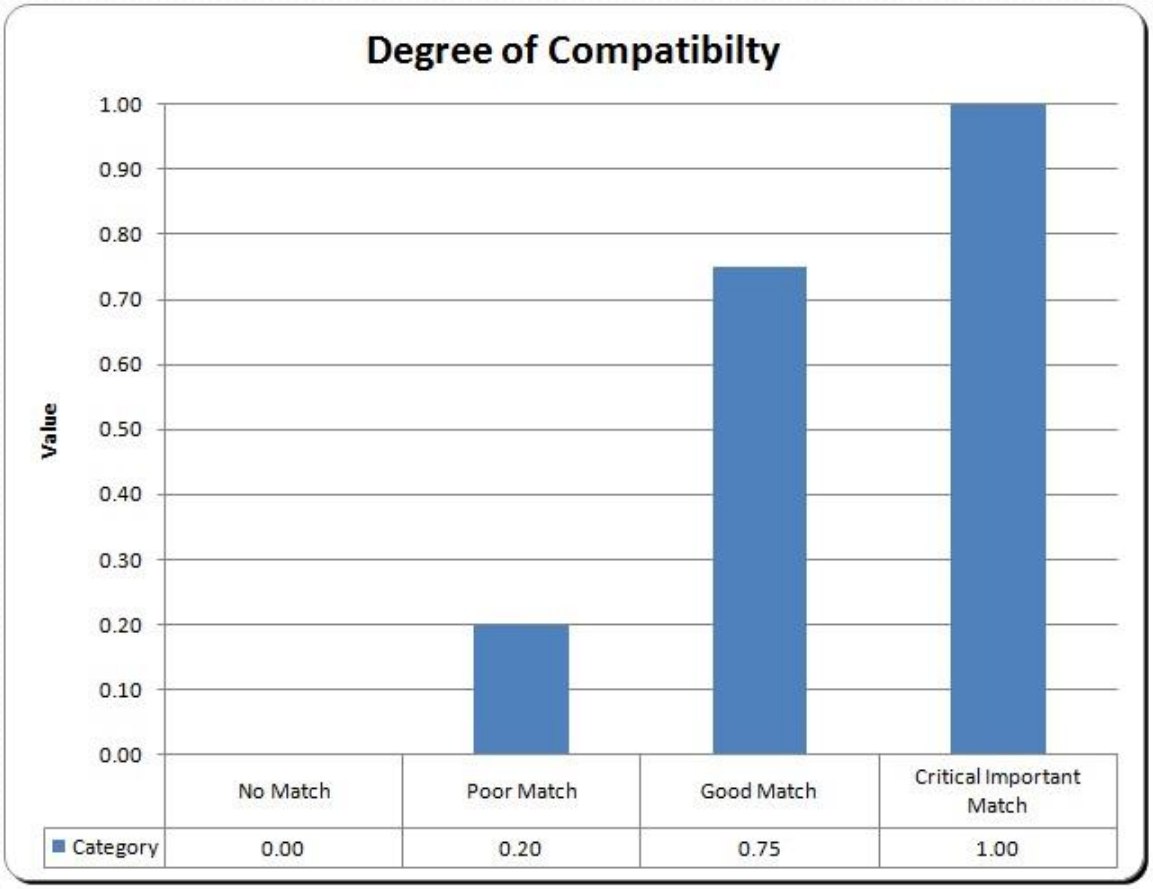
Methodology

- *Value model:*



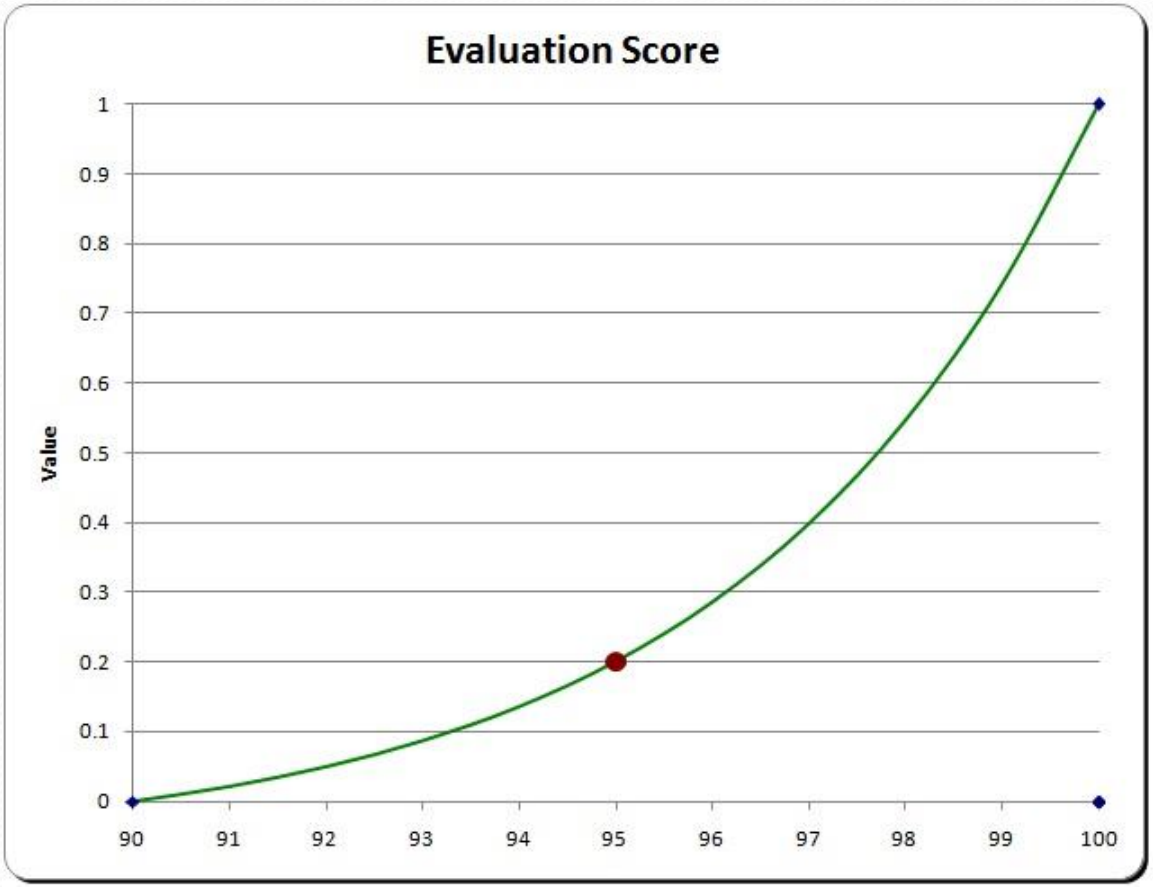
Methodology

- *Value functions:*



Methodology

- *Value functions:*



Methodology

- *Value functions:*

Methodology

- *Weights:*

Criteria	Abroad	In Country
Branch	0.094	0.064
Rank	0.047	0.064
Language Score	0.096	--
Evaluation Score	0.122	0.343
Awards Score	0.041	0.088
Punishment Score	0.031	0.038
Day Point	0.238	--
Graduation	0.014	0.023
Courses	0.029	0.046
Positions Worked	0.010	0.051
Course Success Status	0.039	0.032
Months of Service	0.039	0.020
Degree of Compatibilty	0.200	0.229

Methodology

- Hierarchy Builder Software 2.0 (Weir, 2008)
- Benefit/Cost Ratios
- Assignment Matrices

Methodology

- *Problem Formulation:*

$$\max \sum_{i=1}^{m}\sum_{j=1}^{n} X_{ij}$$

$$st.$$

$$\sum_{i=1}^{m} X_{ij} \le 1$$

$$\sum_{j=1}^{n} X_{ij} \le 1$$

$$\forall X_{ij} \ge 0$$

Sub-Problem 1
(Max. # of Matches)

$$\max \sum_{i=1}^{m}\sum_{j=1}^{n} w_{ij} X_{ij}$$

$$st.$$

$$\sum_{i=1}^{m} X_{ij} \le 1$$

$$\sum_{j=1}^{n} X_{ij} \le 1$$

$$\forall X_{ij} \ge 0$$

Sub-Problem 2
(Max. Weighted Value)

X_{ij} : The assignment of personnel i to a course j
w_{ij} : Weight of assigning personnel i to a course j

Methodology

- *Jonker-Volgenant Algorithm:*

A shortest augmenting path algorithm for the linear assignment problem. It is a special implementation of Dijkstra's shortest path method.

Methodology

- *Post Analysis:*

$$\sum_{j=1}^{n} \frac{\left(\frac{1}{c_j}\right)}{r^*}$$

Equation-1

$$\sum_{j=1}^{n} \left(\max_i \left(\frac{R_{ij}}{r^*} \right) \right)$$

Equation-2

Goodness of Personnel Pool : Eq-2/Eq-1

Goodness of Model : Optimization Result/Eq-2

R_{ij} : The matrix which is set up by ratio s_{ij} to c_j (s_{ij}/c_j)

r^* : The maximum element of matrix Rij

s_{ij} : Score of assigning personnel i to course j

c_j : Cost of course j

Methodology

- *Verification:*
  - MATLAB (R2010a)
  - Previously solved small problems were used.
  - The procedure was repeated 10 times.
  - Previous solutions and Jonker-Volgenant matching algorithm were equal to one another.

Analysis

- *Inputs:*
  - Course requirements
  - Personnel data
  - Normalized benefit/cost ratios
- *Outputs:*
  - Results of Sub-problem (1) and Sub-problem (2)
  - Achievable values
  - Specific matches

Analysis

- *Course Requirements:*
  - Abroad courses

Course	*Branch*		*Rank*			*Graduation*			*Positions Worked*	
	Category-1	*Category-2*	*Category-1*	*Category-2*	*Category-3*	*Category-1*	*Category-2*	*Category-3*	*Category-1*	*Category-2*
Course-1	**B-1**	**others**	**R-2,R-3**	**R-4**	**others**	**Master**	**PhD**	**University**	**P-1**	**others**
Course-2	**B-1**	**others**	**R-2,R-3**	**R-4**	**others**	**Master**	**PhD**	**University**	**P-1**	**others**
Course-4	B-1,B-2,B-4	others	R-3	R-4	others	Master	PhD	University	P-2	others
Course-7	**B-2**	**others**	**R-3,R-4**	**R-5**	**others**	**Master**	**PhD**	**University**	**P-2**	**others**
Course-9	B-5,B-7	others	R-5	R-6	others	PhD	Master	University	P-3	others
Course-10	B-1,B-2	others	R-2,R-3	R-4	others	Master	PhD	University	P-2	others
Course-11	B-1,B-2	others	R-2,R-3	R-4	others	Master	PhD	University	P-2	others
Course-15	B-3	others	R-3	R-4	others	Master	PhD	University	P-2	others
Course-16	**B-6**	**others**	**R-2,R-3**	**R-4**	**others**	**Master**	**PhD**	**University**	**P-1**	**others**
Course-19	B-1,B-3	others	R-3,R-4	R-2	others	Master	PhD	University	P-2	others
Course-20	B-4	others	R-4	R-5	others	PhD	Master	University	P-3	others

Restricted courses

(The ones only in Category-1 in Branch)

B: Branch
R: Rank
P: Position

Analysis

- *Course Requirements:*
  - In country courses

Course	Branch		Rank			Graduation			Positions Worked	
	Category-1	Category-2	Category-1	Category-2	Category-3	Category-1	Category-2	Category-3	Category-1	Category-2
Course-3	B-4,B-5,B-8	others	R-3,R-4	R-2	others	PhD	Master	University	P-2	others
Course-5	**B-1**	**others**	**R-4,R-5**	**R-6**	**others**	**PhD**	**Master**	**University**	**P-3**	**others**
Course-6	**B-1**	**others**	**R-4,R-5**	**R-6**	**others**	**PhD**	**Master**	**University**	**P-3**	**others**
Course-8	B-6	others	R-3,R-4	R-5	others	Master	PhD	University	P-2	others
Course-12	B-1,B-2,B-3	others	R-2,R-3	R-4	others	Master	PhD	University	P-1	others
Course-13	B-1,B-2,B-3	others	R-2,R-3	R-4	others	Master	PhD	University	P-1	others
Course-14	B-1,B-2,B-3	others	R-2,R-3	R-4	others	Master	PhD	University	P-1	others
Course-17	B-5,B-7,B-8	others	R-2	R-1	others	Master	PhD	University	P-1	others
Course-18	B-5,B-7,B-8	others	R-2	R-1	others	Master	PhD	University	P-1	others

Restricted courses

(The ones only in Category-1 in Branch)

B: Branch
R: Rank
P: Position

Analysis

- *Personnel Data:*

Personnel	Branch	Rank	Language Score	Evaluation Score	Awards Score	Punishment Score	Day Point	Graduation	Courses	Positions Worked	Course Success Status	Months of Service
Personnel-1	Branch-1	Rank-3	67	98.36	2.26	0.00	0	University	Two or More Courses	Position-2	79	117
Personnel-2	Branch-2	Rank-3	81	95.84	2.36	0.00	18	Master	Two or More Courses	Position-2	66	166
Personnel-3	Branch-4	Rank-2	92	99.01	2.14	0.00	0	Master	Two or More Courses	Position-3	94	48
Personnel-4	Branch-3	Rank-4	71	94.84	2.56	0.10	0	Master	One Course	Position-1	87	210
Personnel-5	Branch-1	Rank-3	92	100.00	2.11	0.00	14	University	No Course	Position-1	61	159
Personnel-6	Branch-5	Rank-5	91	96.96	3.84	0.16	21	University	No Course	Position-2	93	273
Personnel-7	Branch-6	Rank-4	78	100.00	3.21	0.00	0	Master	Two or More Courses	Position-2	60	233
Personnel-8	Branch-1	Rank-3	92	98.24	1.65	0.00	4	University	Two or More Courses	Position-1	74	164
Personnel-9	Branch-6	Rank-2	75	100.00	2.30	0.00	0	Master	Two or More Courses	Position-1	95	49
Personnel-10	Branch-4	Rank-5	82	96.05	2.98	0.34	10	PhD	Two or More Courses	Position-3	83	271

Analysis

- *Cost of the course:*

Costs of Courses (in dollars)			
Course-1	500	**Course-11**	400
Course-2	500	**Course-12**	340
Course-3	240	**Course-13**	340
Course-4	400	**Course-14**	340
Course-5	320	**Course-15**	380
Course-6	320	**Course-16**	460
Course-7	430	**Course-17**	300
Course-8	240	**Course-18**	300
Course-9	420	**Course-19**	410
Course-10	400	**Course-20**	390

Analysis

- *Normalized Benefit/Cost Ratios:*

	C-1	C-2	C-3	C-4	C-5
P-1	0.340	0.340	0.677	0.499	0.468
P-2	0.000	0.000	0.563	0.281	0.000
P-3	0.000	0.000	0.538	0.524	0.000
P-4	0.000	0.000	0.566	0.339	0.000
P-5	0.356	0.356	0.608	0.371	0.456
P-6	0.000	0.000	0.699	0.208	0.000
P-7	0.000	0.000	0.809	0.366	0.000
P-8	0.400	0.400	0.473	0.463	0.355
P-9	0.000	0.000	0.611	0.380	0.000
P-10	0.000	0.000	0.332	0.391	0.000

Analysis

- *Results:*

Maximum Value by Cost = 13.862
Maximum Value by Cost and Personnel = 12.280

	Total Number of Matches	Overall Value	Max.Value by Cost	Max.Value by Cost and Personnel
Sub-problem 1	20	8.986	64.82%	73.18%
Sub-problem 2	20	11.933	86.08%	97.17%

Goodness of the Personnel Pool = 88.59%
Goodness of the Model = 97.17%

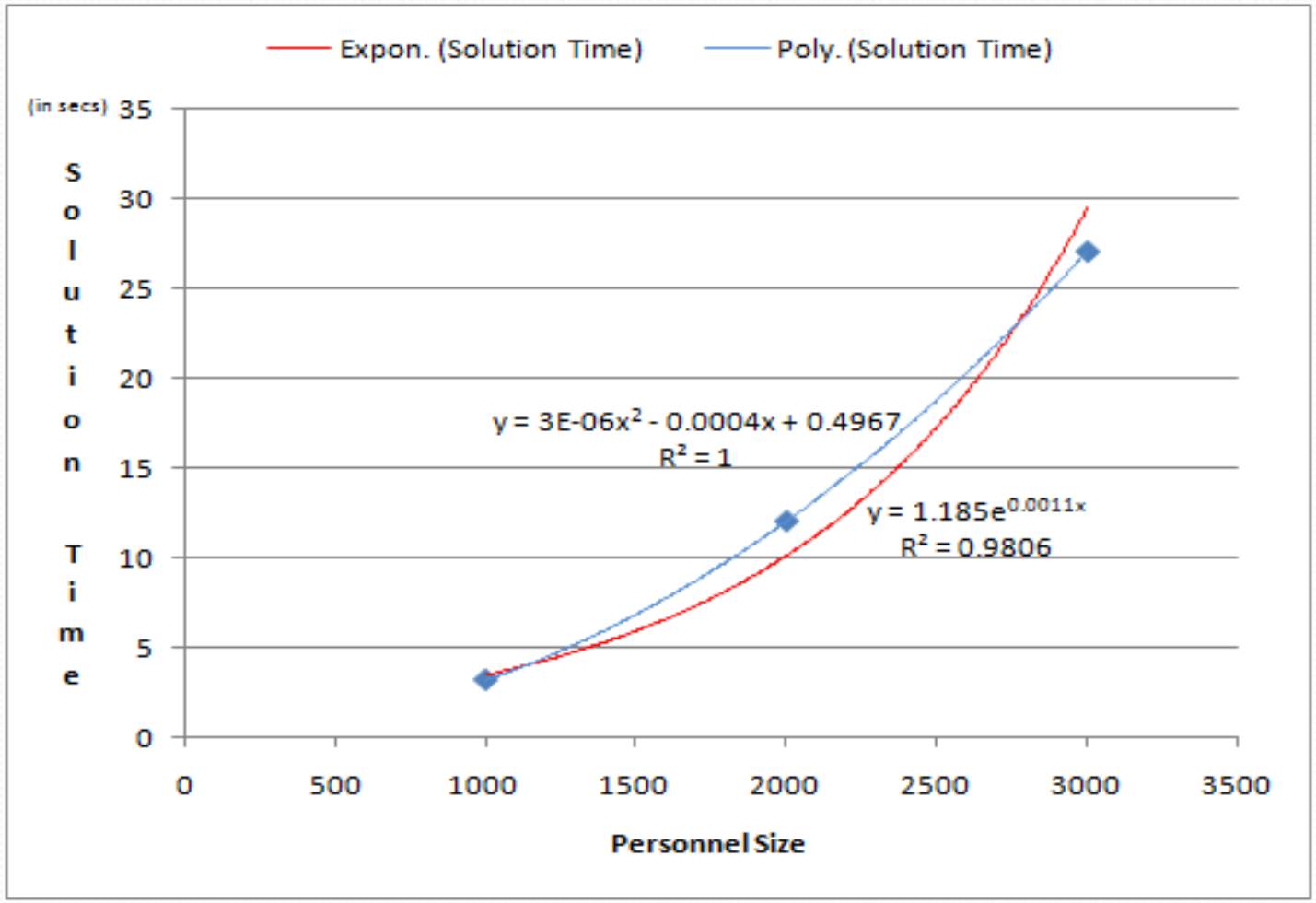
Analysis

- *Post-optimality Analysis:*

		Personnel Size		
Course Size		1000	2000	3000
20	Average Solution Time (CPU time in secs)	3.181	12.057	27.083
	Goodness of Personnel Pool	91.86%	92.21%	92.21%
	Goodness of Model	98.13%	99.12%	99.27%
30	Average Solution Time (CPU time in secs)	3.176	12.011	27.049
	Goodness of Personnel Pool	98.89%	99.05%	99.14%
	Goodness of Model	97.57%	98.45%	98.70%
40	Average Solution Time (CPU time in secs)	3.161	12.015	27.053
	Goodness of Personnel Pool	97.05%	97.80%	97.87%
	Goodness of Model	97.23%	98.14%	98.46%

Analysis

- *Post-optimality Analysis:*



Analysis

- *Post-optimality Analysis:*

Personnel Size	Predicted Solution Time (in secs)
5000	73
7500	166
10000	296
15000	669
20000	1192

Conclusion

- We have a good set of personnel for the case study and algorithm works well.
- We may reevaluate the problem when we do not have a good set of personnel (lower overall value).
- Personnel size has an effect on solution times. However solution time is still very small even for large sizes of personnel.
- The proposed solution methodology finds maximum number of matches in Sub-Problem(1) and maximum weighted value in Sub-Problem(2).

Conclusion

- The optimal solution is achieved in reasonably short time while the current system takes days for assignments and it also does not look for optimality.
- GUIs can be created for flexible solutions.
- A new software can be developed for managing all of these tools.
- Course database has to be generated for using this model effectively.
- To see the picture and provide better utilization for Air Force, all the assignments must have done at the same time instead of course by course matching.

Conclusion

- Although we have an optimal solution, it is still going to be an initial solution and decision support for officials unless the whole model and solution methodology are imported to related TURAF instructions.
- Using this model and solution methodology is going to remarkably decrease the workload of officials.
- This kind of detailed model can make the selection process more objective and reliable which may result with good personnel morale and motivation.

Conclusion

- *Future Research:*
  - Different multi criteria decision analysis methods can be used for the model.
  - Different sensitivity or post optimality analysis methods can be implemented to the problem.
  - Faster solution algorithm, computer program, or computer language can be researched.
  - General course and education plans can be structured according to personnel data, which can be predicted by some probabilistic methods, and value model.

Questions