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Hungarian Technique and Selection of Optimized Plan of Insurance

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Objectives: Customers are generally confused while taking a plan of Life Insurance of India (LIC) which is having huge amount of database stored over the cloud server. The customer has to select the optimum plan for getting insurance either for own or for family members.
Method: The present paper represents use of a mathematical technique for retrieving the optimum policy plan which shall be suitable as per need of the customer. In this regard, a well-known Hungarian technique is applied for selection of best policy plan by the customer. From the literature, it is revealed that the said technique is used by the researchers for optimizing the big data related to business organizations.
Tools Used: A sample of the database is stored into a matrix form and computations have been performed to suggest accurate policy plans based on age, amount of premium, etc. A well know python programming is used to execute the proposed system model.
Testing: The model is tested over the collected data from the LIC of India and computed results are given in the form of tables. The proposed methodology can be used for the business organizations related to the insurance sectors and others.

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Keywords: Customer; database; LIC; policy plan; Hungarian method; optimization.

1 Introduction

From the literature, it is revealed that the assignment problem deals with the assigning the tasks to different machines to receive optimum throughput from machines. The primary goal is to determine the optimal assignment of the tasks in which minimization of the total cost involved and getting the maximize effectiveness of the machines. In this regard, constraints may be set manually when the database is not much long, but it creates problem when huge amount of database exists. For this purpose, users take the help of automation by setting the constraints in such a manner that no two tasks can be assigned to one machine. There are number of existing methods which solve the assignment problem such as simplex method, complete enumeration method, transportation method, Hungarian method, etc. The Hungarian method provides the best possible solution and an effective way by not directly comparing of each result whereas the alternate method is not suitable when sample size of database i.e. n becomes too large. The other name of Hungarian method is Kuhn-Munkres algorithm. It solves the assignment problem in polynomial time and is combinatorial optimization algorithm. Hungarian method solves the problem in $O(n^3)$ time. In the real life, it is common that the cost matrix is not square but in Hungarian method, it is necessary to make the cost matrix square by adding empty entries with 0's or a dummy node hence it limits the cost matrix to be square.

In the present work, a system model is designed using Unified Modeling Language (UML) in the form of class diagram which shows how the LIC database is related to the policy to be opted by the customer. The entire database is converted into the matrix form and thereafter, an optimization technique is used by considering the Hungarian method. The method produces the optimal assignment as well as involvement of the optimal cost. The method is useful for assigning the different plan to different age group of the customers so that the premium amount of the policy must be optimized. It is the responsibility of the administrator of the online system to upload the various plans for the use of the customers. The present work is useful to justify the advantages of assignment technique for best allocation of the plans to the customers of different age groups and ensure the optimum use of the Life Insurance Policy System.

2 Literature Review

UML is used for drafting the blue-print of the research problem; hence, many researchers are using modeling language which is versatile platform independent language and very easy to convert the designed model through any object-oriented programming language. In the year 1997, Object Management Group (OMG) described modelling language which is used in software engineering for designing the models based on the various standards of the UML [1]. Further, OMG presented the UML specifications and shows the graphical notations that are used for creating the visual model of software [2]. In the year 2016, a variant of UML is presented for the development of software-based system [3]. It described the various UML standards which meet the requirement of different circumstances. In 2021, a comprehensive review is given from 2009 to 2019 [4] and finds the UML diagrams are used for the design and modeling. The authors presented the systematic literature survey which makes it easy to analyze and recognize all studies related to UML. Earlier, Booch, et.al. [5] also presented the various software designs and also updated the various kinds UML diagrams.

In the current scenario and due to multiple tasks on the customers in day-to-day activities, it is very difficult to do decision-making in different kinds of situations which may arises the use of assignment problem and it is the special class of linear assignment programming model which allocate the jobs to machines and has the objective either to minimize or maximize based on situation. Let us describe some of the important references on these aspects. In the year 1955, Kuhn developed the Hungarian method [6] for solving the assignment problem. The two Hungarian mathematicians used two theorems and it was named Hungarian method. The algorithm has the complexity of order $O(n^4)$ and it is polynomial in time and that's why the name is also called Kuhn-Munkres algorithm. In 2017, the four Artificial Intelligence (AI) studies were presented namely genetic algorithm, nearest neighbor, neuro fuzzy and ant colony optimization and compared these algorithms [7]. In the year 2018, the concept of Travelling Salesman Problem (TSP) [8] has been illustrated and solved problem by Hungarian method to find the optimal solution and propose the exact distance when the salesman visits the

places of Karnataka state of India. This paper also represents the significance of Hungarian method which uses the assignment model of operational research. The algorithm is coded through Java Development Kit (JDK 1.8) and represented the results in matrix form. In this paper, TSP function is stronger than the other algorithmic approach such as comprehensive approach.

Further, in the year 2018, nonlinear binary problem [9] named as robust assignment problem was developed with linear binary programming problem and modified Hungarian approach to optimize the mean and to minimize the variance of the objective function. The proposed robust assignment problem results that the complexity is same as basic Hungarian method and also provides greater security against damper violation in the presence of unpredictability at increased computational cost. In the year 2019, Hungarian algorithm was implemented as optimization algorithm which solved the problem of assignment in polynomial time [10]. In this paper, the algorithm works even when all the minimum values are same in two or more rows. The author takes the input from the user of nxn matrix which is non-negative number. It takes little amount of time or a fragment of second to perform its computation. In same year, a distributed intelligent algorithm [11] based on Hungarian algorithm was proposed. In this paper urban computing and intelligent novel systems are designed to improve the urban environment and then each fog node gathered the information from its neighboring nodes to find an approximate optimization solution by designing a genetic algorithm. The algorithm shows the various simulation results which achieve shorter delay and less energy consumption than the active work. In 2020, the assignment problem was applied to the course allocation in Nigeria tertiary institution to maximize the lectures effectiveness [12]. The data is taken from the questionnaire from the final year student and then converted this data to cost matrix and form the assignment model and table formulation. Two new efficient methods were proposed which compute gross minimum cost of the assignment problem and compared its solution with the solution of Hungarian method and found that both are executed in minimal time and results are same and it is illustrated through some examples [13]. Further, a new method was also proposed to find the optimal solution by constructing a new cost matrix from the given cost matrix and two matrices are subtracted to obtain the expected cost matrix and expected cost matrix is used for assignment [14]. Dummy cells are not used in this method and used for both balanced and unbalanced assignment problem. Recently, Zhang et al. [15] also used the Hungarian approach for task scheduling related to remote sensing big data. This research work contains all the previous research and methodology related to control of the big data.

3 Methodology

Let us c**o**nsider the database of LIC sample size of 9 customers for demonstration of the approach for opting the insurance by the customers. The customer is willing to obtain the various plans of the policy with minimum premium amount in the minimum time frame. The following Table 1 gives the information of customers alongwith eight fields as Cust_name, Date_of_birth, Age, Policy_no, Plan, Plan_name, Min_Max_age and Sum_Assured.

Table 1. Sample database of LIC of India

Cust_name	Date_of_birth	Age	Policy_no	Plan	Plan_name	Min_Max_age	Sum_Assured
VISHNU KUMAR	01-08-1988	35	247700298	868	Jeevan Azad	0 to50	2,00,000
AMIT KUMAR	26-04-2000	23	247700567	861	Bachat plus	0 to 60	2,00,000
VIJAY KUMAR	01-01-1993	30	208333018	860	Bima jyoti	0 to 55	1,00,000
SHRAWAN KUMAR GUPTA	13-10-1969	54	209445105	914	New Endowment	8 to 55	1,00,000
MAHENDRA PRATAP SINGH	02-02-1960	63	225970469	936	Jeevan Labh	8 to 59	2,00,000
DEVENDRA	25-06-1986	37	229228999	943	Aadhar	8 to 55	2,00,000

Cust_name	Date_of_birth	Age	Policy_no	Plan	Plan_name	Min_Max_age	Sum_Assured
KUMAR PRIYE					Stambh		
KESHAV PRASAD VERMA	23-07-1972	51	236428518	944	Aadhar Shila	8 to 55	2,00,000
VINEET MISHRA	29-07-2000	23	229227436	948	Bima Shree	8 to 55	1,00,000
GOLDEE VERMA	01-01-1995	28	226429038	863	Dhan Rekha	8 to 60	2,00,000

From the above table, data is categorized in the form of matrix by considering the two major fields as Plan and Min_Max_age and represented below in the Table 2 in the form of the assignment problem.

Table 2. Database for proposed assignment model

Plan\Age	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50
868	907	910	935	936	940	948	968	994	1046
861	860	866	892	895	900	912	933	973	1034
860	1149	1154	1177	1178	1181	1190	1208	1244	1306
914	735	738	749	751	756	764	780	807	847
936	443	444	455	456	459	464	475	493	520
943	944	947	971	974	979	991	1012	1047	1099
944	967	971	981	961	985	994	1009	1039	1089
948	966	970	980	981	984	968	1004	1028	1071
863	1868	1876	1879	1881	1888	1904	1890	1933	2046

The above table shows that database is converted into useful data and as formulated for assignment model. In this table, the data is categorized according to the ages related to nine customers which are used to distinguish the customers and insight values represents various plans which is to be allocated to customers for example, Plan 868 can be assigned according to customers varying from age 6-50 years. On this ground a system model is developed by the use of UML and various classes are represented in the following Fig. 1.

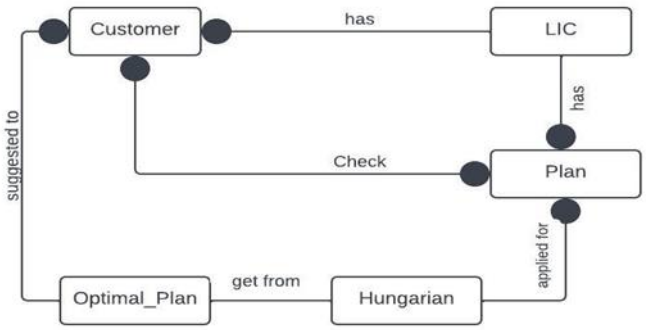

Fig. 1. UML system model

The above UML Diagram has five important classes namely Customer, LIC, Plan, Hungarian and Optimal_Plan in which LIC has many customers and many plans to the customers. But, customers have to need to search best plan for which a Mathematical method i.e., Hungarian rule is applied and it is controlled through the Hungarian class and further optimized plan to get the information for best plan having information about the type of plan as suggested in the table and this class will suggest to customer for selection of best plan.

On the basis of above system model, the following steps are applied for selection of best plan for getting the insurance of the policy:

- *Input the Plan with detail like Plan_no, Plan_name in Input_Plan ();*
- *Arrange Plans in Matrix of Order N*N where N is number of rows/columns as Input_Plan ()← Matrix (N, N)*
- *Apply the Hungarian technique as Hungarian ();*
- *Obtain the Optimized Plan through Selection of Optimal Plan by the Customer as Optimized_Plan ();*
- *Selection of Optimized Plan by the Customer as Selection_Plan ();*

By the use of above concept, Input_Plan() contains information with Plan number and name, thereafter, data is stored over the Matrix(N, N) considered Row as P1, P2, P3……Pn and Column as A1 A2……An. After-that Hungarian() function shall be applied for selection of the Optimized_Plan() for selecting the best plan as Selection_Plan().

On the basis of above, the main module is the Hungarian method [6] which is controlled through following steps:

Hungarian()

Step 1 Check whether number of Row is same as Column i.e. Matrix(N, N)

- When both are same, then called as balanced matrix;
- When both are not equal, then add dummy Row/Column by considering cost as 0 to make as square matrix;

Step 2 Row/Column reduction technique

- Find the minimum element from each row and subtract it from each element of that row and update cost table;
- Find the minimum element from each column and subtract it from each element of that column update cost table;

Step 3 Make the Assignment in the modified table

- Identify exactly single 0 in all rows and mark a square [0] around it to make the assignment and cross all other 0 in the same column of that row which have an assignment;
- Similarly identify exactly single 0 in all column and mark a square [0] around it to make the assignment and cross all other 0 in the same row of that column which have an assignment and form the modified cost table;

Step 4 Check whether number of assignments is equal to number of rows to find the optimal solution

- If solution is optimal then compute optimal cost;
- If solution is not optimal then goto Step5;

Step 5 To cover all the 0, draw a set of horizontal and vertical lines

- Marked all the rows in which no assigned 0;
- Examine marked rows and if any 0 cell occurs in that row, then mark that column;
- Examine marked columns and if any assigned 0 exists in that column, then mark that row;
- Repeat this process until no rows or columns can be marked;
- For each unmarked rows and marked columns draw a straight line;
- If the number of lines is equal to number of rows, then the current solution is optimal otherwise goto Step6;

Step 6 Create the new revised modified cost table

- Select the minimum element from all the cells not covered by any line say m;
- Subtract m from each element not covered by a line;
- Add m to each element which is covered by the two lines;

Step 7 Repeat Step3 to Step6 until an optimal solution is found.

4 Results and Discussion

From the database given in the Table 2 for the checking the feasibility of the proposed method for faster and accurate access of suitable policy plan by the customer, one can design the original cost matrix table which is represented in the Table 3. In this table N is considered as 9 for the sake of computation purpose and one can make the computer program through object-oriented programming then it can be finite number as per the policy plan and number of the customers. It is represented as P_1, P_2,…..P_N for the Plan of the policy while A_1, A_2…… A_N represents Age range of the customers while inside value of cell contains the premium value.

Table 3. The original cost matrix from sample database

Plan\Age	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**	**A_9**
P_1	907	910	935	936	940	948	968	994	1046
P_2	860	866	892	895	900	912	933	973	1034
P_3	1149	1154	1177	1178	1181	1190	1208	1244	1306
P_4	735	738	749	751	756	764	780	807	847
P_5	443	444	455	456	459	464	475	493	520
P_6	944	947	971	974	979	991	1012	1047	1099
P_7	967	971	981	961	985	994	1009	1039	1089
P_8	966	970	980	981	984	968	1004	1028	1071
P_9	1868	1876	1879	1881	1888	1904	1890	1933	2046

By applying the proposed methodology, one can get the following assignment shown in the Table 4.

Table 4. Optimal assignment for selection of optimal policy plan

Plan\Age	**A_1**	**A_2**	**A_3**	**A_4**	**A_5**	**A_6**	**A_7**	**A_8**	**A_9**
P_1	0	**[0]**	1	0	0	4	4	2	27
P_2	**[0]**	3	5	6	7	15	16	28	62
P_3	1	3	2	1	**[0]**	5	3	11	46
P_4	13	13	0	0	1	5	1	**[0]**	13
P_5	35	33	20	19	18	19	10	0	**[0]**
P_6	0	0	**[0]**	1	2	10	11	18	43
P_7	35	36	22	**[0]**	20	25	20	22	45
P_8	35	36	22	21	20	**[0]**	16	12	28
P_9	35	40	19	19	22	34	**[0]**	15	101

By crossing the 0's, one can get the total involvement of the cost and best assignment of the policy plan according to the sample database. This is represented in the following table 5.

The computed results shows that the Customer of Age range (11-15) years (A_2) has to select Plan (P_1) with premium cost of Rs 910 monthly from the LIC Company and similar interpretation is given in the above table i.e. Plan(P_2) to Customer of Age range (6-10) years (A_1) with premium cost of Rs 860 monthly, Plan(P_3) to Customer of Age range(26-30) years (A_5) with premium cost of Rs 1181 monthly, Plan(P_4) to Customer of Age range(31-35) years (A_8) with premium cost of Rs 807 monthly, Plan(P_5) to Customer of Age range(46-50) years (A_9) with premium cost of Rs 520 monthly, Plan(P_6) to Customer of Age range (16-20) years (A_3) with

premium cost of Rs 971 monthly, Plan(P_7) to Customer of Age range(21-25) years (A_4) with premium cost of Rs 961 monthly, Plan(P_8) to Customer of Age range(31-35) years (A_6) with premium cost of Rs 968 monthly, Plan(P_9) to Customer of Age range(36-40) years (A_7) with premium cost of Rs 1890 monthly. The above algorithm has also been computed through programming and similar interpretation is represented in the Fig. 2.

Table 5. Selection of optimal policy plan with optimal premium

Plan	Age	Premium
P_1	A2	910
P_2	A1	860
P_3	A5	1181
P_4	A8	807
P_5	A9	520
P_6	A3	971
P_7	A4	961
P_8	A6	968
P_9	A7	1890
	Total	9068

```
Original Cost Matrix:
 [[ 907  910  935  936  940  948  968  994 1046]
 [ 860  866  892  895  900  912  933  973 1034]
 [1149 1154 1177 1178 1181 1190 1208 1244 1306]
 [ 735  738  749  751  756  764  780  807  847]
 [ 443  444  455  456  459  464  475  493  520]
 [ 944  947  971  974  979  991 1012 1047 1099]
 [ 967  971  981  961  985  994 1009 1039 1089]
 [ 966  970  980  981  984  968 1004 1028 1071]
 [1868 1876 1879 1881 1888 1904 1890 1933 2046]]
optimal Assignment problem result: 9068
[[   0.  910.    0.    0.    0.    0.    0.    0.    0.]
 [ 860.    0.    0.    0.    0.    0.    0.    0.    0.]
 [   0.    0.    0.    0. 1181.    0.    0.    0.    0.]
 [   0.    0.    0.    0.    0.    0.    0.  807.    0.]
 [   0.    0.    0.    0.    0.    0.    0.    0.  520.]
 [   0.    0.  971.    0.    0.    0.    0.    0.    0.]
 [   0.    0.    0.  961.    0.    0.    0.    0.    0.]
 [   0.    0.    0.    0.    0.  968.    0.    0.    0.]
 [   0.    0.    0.    0.    0.    0. 1890.    0.    0.]]
```

Fig. 2. Optimal assignment of policy plan to customer

5 Conclusions

From the above work, it is concluded that huge amount of database of Indian Insurance Policy System is available over the cloud servers. Efficient customers may accesses the database over any hand-held devices categorized as laptop, palmtop, mobile, etc. The above system shall provide the guidelines to select best policy plan according to the age of the customers and accordingly, customers may take plan from any branch of the LIC as depicted in the case study. The above system is limited to the finite number plans controlled by N and also offers given by the LIC and corresponding database is stored over the cloud servers which are herein considered as public clouds. The above system can be extended for other organizations having lagre database.

Competing Interests

Authors have declared that no competing interests exist.

References

[1] Booch G, Rambaugh J, Jacobson I. The Unified Modelling Language User Guide, Twelfth Indian Reprint, Pearson Education; 2005.
Available:http://patologia.com.mx/informatica/uug.pdf

[2] Rumpe B. Modeling with UML", Cham, Springer; 2016.
DOI: 10.1109/IEMTRONICS55184.2022.9795777

[3] Kuhn HW. The Hungarian Method for the Assignment Problem, Naval Research Logistics Quarterly; 1955.
DOI:10.1002/nav.3800020109.

[4] Zaman K. K.Saha S. An Efficient Methodology for Robust Assignment Problem", International Journal of Operational Research. 2018;33(2):239–255.
DOI: 10.1504/IJOR.2018.095199.

[5] Liang Junbin Long, Yuxuan, Mei, Yaxin, Wang, Tian Jin, Qun., A Distributed Intelligent Hungarian Algorithm for Workload Balance in Sensor-Cloud System based on Urban Fog Computing, IEEE. 2019; 7:77649-58.
DOI: 10.1109/ACCESS.2019.2922322.

[6] Solaja O, Abiodun J, Ekpudu J, Abioro, Akinbola M. Assignment Problem and its Application in Nigerian Institutions: Hungarian Method Approach, International Journal of Applied Operational Research. 2020;10(1):1–9.
DOI: ijorlu.liau.ac.ir.

[7] Hussein HA, Shiker MA. Two New Effective Methods to find the Optimal Solution for the Assignment Problems", Journal of Adv Research in Dynamical & Control system. 2020;12(7).
DOI:10.5373/JARDCS/V12I7/20201983.

[8] Mismar M. Solving the Assignment Problems Directly Without any Iterations", IOS Journal of Mathematics (IOSR- JM). 2020;16(1):29–34.
DOI: 10.9790/5728-1601032934.

[9] Brucal Stanley Glenn E, Elmer Dadios P. Comparative Analysis of Solving Traveling Salesman Problem using Artificial Intelligence Algorithms, In Humanoid Nanotechnology, Information Technology, Communication and Control Environment and Management, IEEE 9th International Conference. 2017; 1-6.
DOI: 978-1-5386-0912-5/17.

[10] Akshita S, Kumar KA, NethrithaMeda M, Sowmva R, Pawar RS. Implementation of Hungarian Algorithm to Obtain Solution for Travelling Salesman Problem", 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT). 2018;2470-2474.
DOI: 10.1109/RTEICT42901.2018.9012439

[11] Hatice Koc, Erdoğan, Ali Mert, Barjakly, Yousef and Pekeret, Serhat, UML Diagram in Software Engineering Research, A Systematic Literature Review, Multidisciplinary Digital Publishing Institute proceedings, Proceedings. 2021;74(1):1-13.
DOI: 10.3390/proceedings2021074013

[12] OMG, Unified Modelling Language Specification; 1997.
Available:https://www.omg.org/spec/UML/1.4/PDF

[13] OMG, Unified Modelling Language Specification (UML) version. 1999;1:3.
Available: http://www.rational.Com/media/uml/post.pdf.

[14] Ekpenyong AD, Madu IM, Usman S. Implementation of Hungarian Procedure Using C++", (Case study of Dangote flour mills); 2019.
DOI: 10.1504/IJOR.2018.095199

[15] Zhang S, Xue Y, Zhang HK. Li and R. Liu. Improved Hungarian algorithm–based task scheduling optimization strategy for remote sensing big data processing, Taylor and Francis Online; 2023.
DOI.ORG/10.1080/10095020.2023.2178339

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