***Optimal Impression* User Manual**

**0. Introduction**

My student tour guide reinforced my desire to attend Exeter. If Exeter were able to offer each applicant a custom tour, provided by a guide sharing the same gender, boarding status, and academic, sports, and club interests, everyone would benefit. I had this in mind when Exeter alumnus, Lloyd Shapley was awarded the 2012 Nobel Prize in Economics for his contribution to matching theory. Curious, I researched the algorithm for the Stable Marriage Problem. Excited, I realized that I could adapt and implement this algorithm to optimize tour guide assignment. This was the genesis of Optimal Impression, which I developed last summer.

**1. Schedule**

Upon launching Optimal Impression, a user is presented with the Schedule screen, providing the user with a visual representation of Admissions appointments for the current week. Each column represents a day of the week, with time slots displayed vertically, within each day. Buttons, displaying the names of applicants, are located within the applicants' appointment time slots. Pressing one of these buttons provides access to the applicant information captured by Exeter Admissions. The coloured rectangles beside the applicant buttons have the following significance:

Black: Applicant does not require a tour guide (coming for an interview, only);

Red: Applicant has no assigned tour guide;

Green: Applicant has an assigned tour guide.

Previous week / Next week buttons, as well as the date fields at the top of the screen, enable the user to navigate between different weeks of appointments. The “Change Menu” combo box enables the user to access Optimal Impression's Seasonal Schedules, Guide Data, Matching Parameters, Guide Assignment, and Matching Statistics windows and functionality.

**2. Seasonal Schedules**

The user establishes the seasons (eg: trimesters) during which different schedules are in effect. Next, the user must input the specific time slots during which tours will be offered, by season, and day of week. At Exeter, these slots usually correspond to class schedules since students serve as guides.

**3. Guide Data**

This screen provides the user with the ability to view the guide data available to Exeter Admissions, by pressing the button corresponding to any guide of interest.

**4. Matching Parameters**

The user may input weights that will be used to prioritize different criteria in the matching of tour guides to applicants. The greater the weight, the higher the priority of a matching criterion. When all of the weights are set to zero, guides are randomly assigned to applicants.

**5. Guide Assignment**

To assign guides to applicants for a particular week, the user must navigate to the week in the Schedule screen. Next, the user must select "Guide Assignment" from the "Change Menu" and press "Go." When the guides have been assigned, the Schedule is refreshed with green rectangles replacing red. A user pressing an applicant button will see the guide he/she has been assigned. Further, should the assigned guide fall ill and need to be replaced, the user is able to override the automatically assigned guide with a manual guide selection (eventually, available replacement guides will be sequenced from best to worst, as a function of the weighted matching criteria).

**6. Matching Statistics**

The user may assess the quality of the Guide Assignment by reviewing the associated Matching Statistics. This screen reminds the user of the criteria weights employed in producing the current Guide Assignment. It also displays the frequency with which different characteristics are shared by guides and applicants, as well as the overall average number of characteristics shared by guides and applicants, in the current Guide Assignment. The Matching Statistics help a user hone his/her Guide Assignment by giving him/her a feel for which weights should be increased/decreased. This, in conjunction with the ability to produce multiple Guide Assignments until he/she is satisfied, enables the user to produce the best possible Guide Assignments for his/her context. In manually assigning guides to applicants, Exeter Admissions prioritizes shared gender and guides that are one grade ahead of applicants. In performing a three-scenario case study with randomly generated data, I obtained the following results:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Weighted Criteria** | **Gender** | **Grade** | **Boarding** | **Academic** | **Fall** | **Winter** | **Spring** | **Club 1** | **Club 2** | **Matches** |
| **Random Assignments** | 54% | 27% | 62% | 28% | 6% | 3% | 1% | 15% | 10% | 2 |
| **Gender + Grade** | 90% | 75% | 66% | 25% | 5% | 4% | 0% | 14% | 12% | 3 |
| **All Matching Criteria** | 86% | 70% | 85% | 65% | 15% | 8% | 2% | 34% | 15% | 4 |

This case study demonstrates that at the cost of only small decreases in shared Gender (4%) and Grade (5%), it is possible to increase the average number of shared characteristics between guides and applicants from 3 (Gender + Grade) to 4 (All Matching Criteria).

**7. Data**

Due to the confidential nature of actual Applicant and Guide data, this beta version of Optimal Impression has been developed with randomly generated test data. I have used estimates, provided by Ms. Waleryszak of Admissions, to develop a random Applicant generator and a random Guide generator that can produce different sized data sets, characterized by the distribution of attributes found in actual Applicant and Guide data, respectively. Optimal Impression is being provided to the user along with three weeks of data reflecting the maximum problem size encountered by Ms. Waleryszak - a week in which there are 200 potential guides for 150 visiting applicants. If there were no schedule conflicts (ie: potential guides had no classes), a problem of this size would have 1.38 x 10112 possible solutions.

The data used by Optimal Impression is found in the following files:

|  |  |  |
| --- | --- | --- |
| **Test Applicant Data Files** | **Test Guide Data File** | **Other Files** |
| Monday\_8\_16.txt | Guides.txt | ParameterWeights.txt |
| Tuesday\_8\_17.txt |  | Fall.txt |
| Wednesday\_8\_18.txt |  | Winter.txt |
| Thursday\_8\_19.txt |  | Spring.txt |
| Friday\_8\_20.txt |  | Summer.txt |
| Saturday\_8\_21.txt |  |  |

Mathematicians/computer scientists would consider my guide assignment formulation a weighted matching problem within a bipartite graph. Each member of the set of guide nodes is connected to each member of the set of applicant nodes with an arc. A weight, representing the relative benefit of assigning a particular guide to a particular applicant, is associated with each arc. This weight is the sum of user-set parameters reflecting the desirability of guides and applicants one year apart, sharing the same gender, boarding status, and academic, sports, and club interests. If a particular guide is not available to provide a specific applicant a tour, the arc weight is zero. Alternatively, if a particular guide is available to provide a specific applicant a tour and they share characteristics, the arc weight is positive. The optimal matching consists of the subset of arcs that maximizes the sum of weights.

1.38 x 10112

possible solutions

Guides

Applicants

Up to 200/week

Up to 150/week

F, U, B, S, , H, , E,

M, U, B, S, , , L, E,

F, L, B, L, , , L, M,

F, L, B, S, , , L, M,

Sample Weights

10,10,5,5,5,5,5,3,2

30

23

25

**G**

**A**

Identifying the optimal matching might seem straightforward - simply select the greatest weight guide per applicant. Unfortunately, proceeding applicant by applicant does not guarantee a superior solution. What if a guide is best for numerous applicants? The domino effect from making the wrong assignment might result in an inferior overall matching than would have been possible. I turned to the Gale-Shapley algorithm for help. In step one, the weights establish a vector of preferred guides for each applicant. In step two, the weights establish a vector of preferred applicants for each guide. Next, in an iterative process, an attempt is made to assign each applicant his/her preferred guide. When a conflict arises, guide preferences, which provide perspective across applicants, are used to break ties. The algorithm terminates with stable guide assignments - for any paired guide G and applicant A, there does not exist an alternative pairing in which both G and A are individually better off than in the current pairing. The Gayle-Shapley algorithm finds a solution for the Stable Matching Problem in O(n2) time.