Problem Description

Matching the right people to the right job is an important activity in any organization. In order to ensure the organization runs smoothly and people have the opportunity to grow within the organization it is often important that they move people between jobs. Whether the organization has many jobs located at the same location or varying locations, it is often able to group these jobs by level of experience needed to hold them. Given a set of people with varying levels or experience and jobs with varying requirements and value to the organization, one problem that needs to be solved is the assignment of these people to the jobs in a way that best benefits both the employer and the employee. The United Sates Air Force is one such organization.

The Air Force flies a variety of aircraft, and this project is based on the C-17. The C-17 has a variety of missions to include hauling cargo and personnel in wartime and peace time as well as providing airdrop of cargo and personnel. To facilitate the air drop mission some pilots are sent to extra training to help plan these missions. The Air Force having spent money to specially train these individuals wants to get the best return on their investment and has coded several positions within the Air Force that require these officers with special skills. The jobs are grouped in three levels of training and experience and can only be filled by these officers. Unfortunately, these officers are also capable of filling many other jobs within the AIR Force and may not be available and some jobs may go unfilled. The Air Force would like to tool to assign the available personnel to vacant jobs in a manner that is most beneficial to the defense of the United States

The following is a mixed integer programming (MIP) formulation of the personnel assignment problem.

$$\max \sum_{i=1}^{n}\sum_{j=1}^{n} v_{ij}x_{ij}$$

$$s.t.$$

$$\sum_{i=1}^{n} x_{ij} \le 1 \qquad \forall j \quad \text{(each job gets at most one person)}$$

$$\sum_{j=1}^{m} x_{ij} \le 1 \qquad \forall i \quad \text{(each person gets at most one job)}$$

$$xij \in \{0,1\} \qquad \forall i, j$$

Where, v_{ij} is the value to the Air Force of filling job *j* with person *i* and; x_{ij} is a binary variable that takes a value of 1 if person *i* is assigned to job *j*, and 0 otherwise.

The assignment problem is not unique to the Air Force, but each assignment problem is unique based on the rules on how to calculate the value of filling the job and whether or not as person can fill a job. Since the Air Force has Microsoft Office on every computer they would prefer the tool be built in Microsoft office using Visual Basic for Applications

A Heuristic Approach

This formulation is a generalized assignment problem. One can solve this problem to optimality; however, the solution times are far too long. Fast heuristic procedures can be used to solve the problem, allow interactive use, and facilitate sensitivity analysis. Below is an example of a heuristic that can be used to solve the problem. This heuristic consists of the following two phases: (1) Assign each person to a job based on a penalty defined as the difference between the best and the second best assignment. (2) Perform a two-opt exchange procedure in which people are considered two at a time and reassigned if the new assignment increases the total value of the objective function.

(A) Penalty-based assignment

(1) For each person *i*, calculate its penalty: Penalty (*i*) = the difference between the value of the best available job and the value of the second best available job. A job is available to a person if it meets several criteria to be explained when we next meet. Sort the people in increasing order of penalties. Assign the people (starting with the

ones at the top of the list) to jobs. Recalculate the penalty of a person if one of its two best jobs becomes unavailable. If a person only has one job available then their penalty is infinity.

(2) Assign to a dummy job the people that could not been assigned to the existing jobs because of unavailability. Set the penalty of each of these people to infinity.

(B) Two-opt exchange

(3) For each pair of people *i* and *j*, already assigned to jobs *x* and *y*, identify a pair of jobs *k* and *l* such that $k \neq x$ or $l \neq y$. Assign person *i* to job *k* and person *j* to site *l* if the total value increases. (the dummy job can be used for exchanges)

(4) Repeat step 3 until no further improvement can be obtained.

Excel Spreadsheets (User Interface)

1. Build a spreadsheet that allows a person to input important information about themselves. See the attached workbook as an example. This should be a standalone spreadsheet that can be sent to individuals to be filled out and then imported into a tool to solve the assignment problem.

2. Build an input sheet for the assignment officer that allows them to input information about a job (location, qualification, years empty, etc.) see example workbook and import user data. This part should also allow the assignment officer to automatically email people based on the emails they provide.

3. Build a tool that takes the inputs from the people and the assignment officer and solves and assignment problem to maximize the value of the jobs filled for the Air Force.

4. Build a sheet that presents the final solution (the assignment of people to jobs). Allow the user to perform sensitivity analysis by changing some of the value function numbers and job availability criteria.

5. The final solution should also be able to be viewed on an interactive map (see example workbook2)

Note: There are many heuristics to solve an assignment problem, this is just one that is available, and we discuss others in class