The importance of having efficient evacuation plans for shopping malls is immediately seen due to their size and number of public attendees. In this particular evacuation model, we were presented with new challenges that were not seen in our previous evacuation models. This shopping mall has several stairwells/elevators in addition to multiple exits. Thus, the attendees of the shopping mall have two sets of evacuation combinations to choose from, therefore making this evacuation plan a transshipment problem. In addition, the number of mall attendees varies throughout the day so functions of time were introduced into the demand constraints. This Linear Programming (LP) problem was solved with the Simplex Method of Operations Research, and the optimal solution was obtained.

The University of Wisconsin-Eau Claire’s Math Department has been creating evacuation and optimization plans for 6 years and has had many novel results. These are given in the following list:

- Dane County: Sandbag Distribution
- Clark County: Evacuation of Owen City
- Eau Claire: Luther Midelfort Hospital
- Eau Claire: Evacuation of Eau Claire City

Since in a shopping mall the number of attendees vary throughout the day, we were faced with 00:00:00 and .99999 is 23:59:59 by using this system. Times are stored as decimal numbers between .0 and .99999, where .0 is subtract, or compare dates and times just like any other numbers, and all dates are manipulated.

Using these converted values to construct a function in time for the demand constraints. Converting time values in Excel into a decimal value

\[ f(t) = \max \left\{ 30 \sin \left( \frac{24t}{24} \left( 1 - \frac{t}{24} \right) \right), 0 \right\} \]

for \( 0 \leq t < 1 \).

The underlying assumptions that went into this model are:

- We are working with a transshipment problem.
- The mall is broken up into 32 sections where attendees are located.
- There are 8 exits and 10 elevators/stairwells.

Each decision variable in the objective equation has a coefficient \( C_{ij} \) that represents the cost of transporting one mall attendee from supply point \( i \) to demand point \( j \). The following objective equation then represents the time to evacuate mall attendees.

\[ \min Z = \sum_{i=1}^{8} \sum_{j=1}^{32} C_{ij} X_{ij} \quad \text{subject to} \quad \sum_{i=1}^{8} X_{ij} \leq A_j \quad \text{and} \quad \sum_{j=1}^{32} X_{ij} \geq B_i \]

where the \( X_{ij} \)'s represent the number of mall attendees who are in section \( i \) of the shopping mall and are being evacuated to demand point \( j \), the \( A_j \)'s are the total number of mall attendees who use elevator/stairwell \( j \) (or exit for first floor) and the \( B_i \)'s are the total number of mall attendees in section \( i \) of the shopping mall for \( i = 1 \ldots 32, j = 1 \ldots 8 \).

In the standard transportation problem, shipments are only allowed from a supply point to a demand point. However, in many scenarios, including this evacuation plan, shipments are allowed between points. The elevators and stairwells are known as the transshipment points for all mall attendees on the second through fourth floors of this mall.

Model still solved using techniques that are used for the original transportation model.
- Transshipment points can be solved by iterative runs of the Simplex Method
- We set the constraints by \( \sum_{j=1}^{32} X_{ij} = B_i \)

The completed program is an example of a dynamic evacuation model that can be run for any given time of the day. To illustrate such a solution, we have drawn to model the evacuation for 12:00 PM. Below, you will find the solution tableau for the second part of the transshipment problem.

We post this solution because one can easily see how many mall attendees in general use a given elevator/stairwell in addition to which exit they use once on the first floor.