

Bus Trip Lottery Process

Mar. 16, 2012

Randy Simons

Goal: Ensure as many people as possible get on one trip before anyone gets on two, as many people as possible get on two trips before anyone gets on three, etc. As much as possible within the constraints of the previous statement, give each person requesting a trip an equal chance to get that trip.

The Process:

Step 1- Set Up Spreadsheet

Create a row in the spreadsheet for each application received. Columns are:

- A. drawing number - blank for now
- B. application number - identifier assigned sequentially as rows are added
- C. name 1 - name of the first person on the application
- D. name 2 - name of the second person on the application, if any
- E. trip A - contains 'x' if application is for trip A
- F. single male A - contains 'x' if application is for a single male on trip A
- G. single female A - contains 'x' if application is for a single female on trip A
- H. A seat - blank for now
- I. trip B - like trip A
- J. single male B - like single male A
- K. single female B - like single female A
- L. B seat - like A seat
- M. multiple applications - if one or both names on the application appear on other applications for other trips, place the application number(s) of the other applications here, and make the background of this cell and the application number cell beige colored. If there are two names on the application, and one appears on multiple applications while the other does not, make the background of the first name yellow (indicating multiple trips applied for), and the background of the second name green (indicating only one trip applied for). Ensure the other applications listed in this column have the equivalent cross reference(s) and background colors.
- N. board / free leader - contains 'x' if one or both names on the application are board members, leaders drawn for a free trip, or someone who for any reason is guaranteed a seat on the given trip

Step 2 - Allocate Board / Free Leader Seats

- sort so all applications with an 'x' in the 'board / free leader' column are at the top
- within those applications, sort so all applications with an 'x' under 'trip A' are above 'trip B' applications
- for 'trip A' applications, allocate seats sequentially, starting with 1, by placing one or two numbers in the 'A seat' column. If the application is for a single, change the 'x' under the single column to the next highest number of singles in that column
- do the same for 'trip B' applications

Step 3 - Allocate Uncontested Seats

No lottery is necessary for any bus trip for which there are more seats available than applicants. For such trips, for each applicant that is marked as having multiple applications (column M), find the other applications (for other trips) and move them up one group (for example, from **Group 0** to **Group 1**).

Step 4 - Drawing

Count the number of applications that don't yet have a seat assignment. Make that many slips of paper numbered sequentially. Draw the slips randomly and enter each drawn number in the 'drawing number' column starting with the top unassigned application and working sequentially down the page. When finished drawing, sort these rows by drawing number.

Step 5 - Allocate Lottery Seats

- everyone begins in the same group, **Group 0**. (The number of the group indicates the number of trips that person has been selected for)
- for each application in **Group 0** (in drawing number order), allocate seats sequentially, continuing after the last seat previously assigned, by placing one or two numbers in the 'seat' column for the appropriate trip. If the application is for a single, change the 'x' under the single column to the next highest number of singles in that column
- As each application is assigned seats, if there is an entry under 'multiple applications', move applications for other trips to the next higher group. For example, if their application for another bus trip is in **Group 0**, move that application to **Group 1**. If the application contains one person who already has a seat on another trip, and another person who has none (green/yellow background), take the average and put them in **Group 0.5**.
- When only two seats are left on a trip, check the number in each single column. An odd number will require skipping down the list until finding a match to fill out that room assignment. If there is no match, then the last single drawn will have the seat unassigned, and the next couple will be given the seats.
- If **Group 0** is exhausted before all seats are assigned, continue with **Group 0.5** (if any), then **Group 1**, then **Group 1.5**, etc., after resorting each group by drawing number.

Step 6 - Reserve List Order

When all seats are assigned for all bus trips, sort by 'bus trip A' (column E), etc. to separate bus trips. For each trip, sort each group above **Group 0** by drawing number again for position on the reserve list.

Step 7 – Adjustments:

- When all reserve lists are ordered, look for adjustments that need to be made:
- For each trip, beginning with the first person on the reserve list, look for anyone with a seat assignment for that trip that is on at least two more trips than the person on the reserve list. If any are found, choose the ones where the difference is greatest, then among those choose the one who was drawn last. (A different choice may be necessary to ensure gender/single/couple matching.)
- Swap positions of the two people, and move the person swapped onto the reserve list so they are placed in the correct group, that is, after others on the list who are still now on fewer trips.
- Continue working through the reserve list until no one remains in the seat assignments who is on two more trips than the next person on the reserve list.
- Repeat this process for each bus trip.

Rationale

The first time Angela and I did the bus trip lottery, we followed the simple and naive process of drawing for each bus trip as a separate lottery. This resulted in several cases where some people got on both trips while others got on none. It didn't take long for the people with no trips to notice this, and they were understandably upset. "How can you imagine this is fair?," they asked, and we had to agree, it's not. We felt we could do better, giving more people an opportunity to participate in the bus trips each year. Thus was born the search for a better lottery process.

After getting input from board members, we came up with a proposal which was further modified based on more input. The new process was used in November 2011, and successfully met the goal at the top of this document. That is, we maximized the number of unique individuals that were given seats in the lottery.

It is important to note that this process only determines who is *initially* assigned a seat. Every applicant who does not get a seat is placed on the reserve list. Most trips in the last few years have had enough cancellations to allow space for everyone on the reserve list to get a seat, if they still wanted it when it became available. In fact, it's common for there to be a couple seats empty when the bus departs, because the reserve list has been exhausted, and no one remained who wanted the seats. So even if you don't get a seat in the lottery, you still have a very good chance of being offered a seat later.

It has been suggested that we allow people to specify first and second choice for trips. This would complicate the process even more. For example, what do you do if one application is marked first choice for one roommate and second choice for the other? This would also either a) tie our hands so we couldn't swap applicants between trips, if we honor first choice above all else, or b) could become a source of discontent with the outcome - "Why did I only get my second choice?". Thus we prefer not to add one more constraint to the process.

Effect of Multiple Sign-ups On Bus Trip Lottery Outcomes

The new bus trip seat allocation process we devised where all bus trips are considered together, has different statistical behavior from earlier lotteries. Previously, each bus trip was treated independently, so signing up for one trip had no effect on your chances for getting a seat on another trip. As pointed out above, this frequently lead to a situation where one person would be drawn for two trips, while another got none. The new process changes the situation so now signing up for multiple trips will increase your chances overall, but will reduce your chances to be drawn for any particular trip.

There are several factors that affect your chances to get a seat on a particular bus trip when you sign up for more than one trip. Here are some contrived and extreme examples to attempt to clarify what's going on.

Example One: Chance Is Divided by Number of Trips

Given two trips A and B, 50 seats available on each. Given 25 applicants for trip A only, 25 applicants for trip B only, and 50 applicants for both. It's easy to see you can give everyone a trip by splitting the applicants for both trips in half, putting 25 on each trip. The number of applicants who get trips are:

- applicants for only A: 100%
- applicants for only B: 100%
- applicants for both on A: 50%
- applicants for both on B: 50%
- applicants for both on either A or B: 100%

So everyone has a 100% chance of getting a seat. But for people who signed up for both trips, only 50% got A, and 50% got B. This is a direct result of the new rule that everyone gets one trip before anyone gets two.

Example Two: Chance Is Inversely Proportional to Number of Applicants

Given two trips A and B, 50 seats available on each. Given 50 applicants for trip A only, and 100 applicants for trip B only. Clearly, everyone who signed up for trip A gets a seat, but only half the people who signed up for trip B do:

applicants for only A: 100%

applicants for only B: 50%

This has nothing to do with the new lottery, it was just as true in the old system. The more applicants there are, the lower your chances to get a seat.

Example Three: Applicants Are Moved from Oversubscribed to Undersubscribed Trips

Given two trips A and B, 50 seats available on each. Given 50 applicants for trip A only, and 50 applicants for both. The solution that gives the most people a trip is to put all the A only applicants on trip A, and all the applicants for both on trip B:

applicants for only A: 100%

applicants for both on A: 0%

applicants for both on B: 100%

The way this actually works in the new process is as follows. Once everyone has either been given a seat or placed on the reserve list for all trips, we look to see if one trip still has seats available and another has people on the reserve list that haven't gotten a seat anywhere. We can open up a seat for someone on the reserve list by moving someone who signed up for both trips off of the full trip and onto the trip that has openings. This effectively reduces the chances of applicants for both trips to get the trip that is full, with the most extreme case being shown in the unlikely example above. In many cases, this situation will not come up, and in fact, it did not arise in the November 2011 lottery.

Summary

Overall, you can see there are several reasons why signing up for multiple trips reduces your chances to get any particular trip, and may reduce your chances even further to get the trip with the most applicants. When you sign up for multiple trips, we take that to mean that it's OK with you to be put on any of those trips. Put another way, if we asked someone, "Would it be OK to move you from trip A to trip B so Millicent can go on a trip - otherwise, she gets none this year?", we are assuming this is the kind of club whose members would answer "Sure, no problem." Millicent will be grateful, and remember, someday you may be in her position.