BANA Simulation Modeling Final Project

Career Fair Simulation Optimization

Date: 17/04/2014

Prepared By:

Yue Zhao
Computer Engineering
M03829949
zhaoy9@mail.uc.edu

University of Cincinnati, Ohio

1. Background

University of Cincinnati (UC) holds the career fair twice a year and Career Development Center (CDC) along with Lindner Career Service keep the following procedures. The student needs to sign in at the front door by swiping their student ID at the registration station. A name tag with their graduation year and major will be printed and their attendance is recorded in the system for the future reference. While leaving, the student is invited to take a survey in the paper form and get the raffle tickets sponsored by CDC. CDC also recruit several volunteers, for directing students from the entry to the registration station and inviting students to fill a post-survey while students leaving.

2. Simulation environment and purpose:

The registration is required upon arrival and this year (2014) there are 5 registration stations so at most five people could sign in at the same time. The survey procedure is voluntary and there are five tables for filling surveys; at most five people could fill out the survey at the same time. The main model is to simulate from students' arrival to their leaving the site for the entire career fair. The purpose is to understand how many registration tables, survey tables and volunteers could lead to the situation that most of the students could attend the career fair, fill out the post-survey and at the same time do not use too much time on waiting in the line.
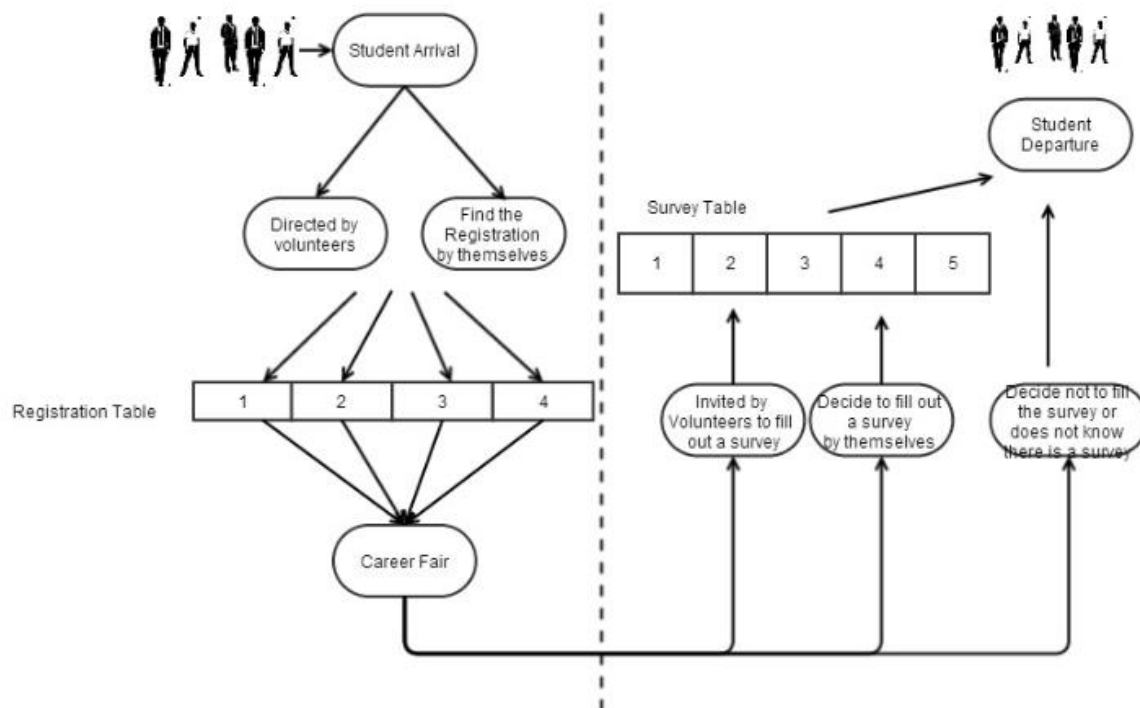

Fig2. Simulation Environment

3. Project Input and Conditions

1. The career fair ran on Feb 19th, 20th and 21st 9 a.m. to 3.p.m. for different themes and we only simulate for one day and assume the two other days are the same.

Date	Event	Time
Wednesday, February 19, 2014	**Professional, Design, & Diversity Career Fair**	9 AM to 3 PM
Thursday, February 20, 2014	**Technical Career Fair**	9 AM to 3 PM
Friday, February 21, 2014	**Interview Day**	9 AM to 3 PM

So simulation time is in total 360 minutes, and according to the observation the interarrival time is divided into three time periods.

9:00 a.m. – 11:00 a.m.	Exponential(0.12) -> 8 people/ minutes
11:00 a.m. – 1:00 p.m.	Exponential(0.08) -> 12 people/ minutes
1:00 p.m. – 3:00 p.m.	Exponential(0.2) -> 5 people/ minutes

2. UC recruit several volunteers for:
   - Direct people to registration desk – 4 people
   - Invite people to fill out the survey – 2 people

Volunteer information is provided below:

2:00PM - 2:30PM	Coat Check (4)	All slots filled ✓ Cierra Mitchell ✓ Aarin Miller ✓ Daniel Cooperider Graduate Salea Leadership Club ✓ Jonathon Colyer Graduate Sales Leadership Club
	Direct Students to Event Registration (4)	All slots filled ✓ Yifan Zhang ✓ Wuxun Zhuo CMA ✓ Ashley Earman ✓ Rachael Sparks

From 9:00 a.m. to 3:00 p.m. there are always 4 volunteers for directing students to event registration and 2 volunteers for inviting people to fill out the survey.

Arbitrarily one of the volunteers for directing students would take a 5 minutes break every 30 minutes. Volunteers for directing students would take the break in turn.

Arbitrarily one of the volunteers for inviting students to fill the survey would take 5 minutes every 30 minutes. Volunteers would take the break in turn.

3. Constantly there are 5 registration table and 5 survey table.
4. If a student notice that the waiting queue for registration table is too long (more than 30 people), the student has 20% possibility to leave the career fair.
5. Without the help of the volunteers, students would still find the registration table so they would not wait for volunteers but will directly find the registration table. In other words, the waiting queue for registration volunteer is zero.

   Under the help of registration volunteer, the student would find the registration table in 3 seconds to 12 seconds. Without the help of volunteers, the student would find the registration table in 30 seconds.

6. Registration procedure would take Triangular distribution (0.15, 0.4, and 1.5) minutes.
7. The student would stay in the career fair for interviewing for Triangular distribution (5, 30, and 70) minutes.
8. The possibility of students to do the survey is highly affected by volunteers. If there are no volunteers inviting them at the time, 50% people would choose to fill the survey. If a student is served with a volunteer for explaining the survey, the possibility that the student fills the survey is 80%.

   If the students decide to take the survey find there are more than 40 people waiting for the survey table, they will choose not to take the survey.

4. Results

Based on the condition described in the previous section, 100 replications in Arena Simulation Software return the following results.

Average Total time in the system (not taking survey)	54.83 minutes
Average Total time in the system (taking survey)	74.22 minutes
Average Waiting Time for Registration table	17.95 minutes
Average Waiting Time for Survey Table	19.71 minutes
People arrive(people in)	3101
People leave directly upon arrival	486
People leave the system taking survey	764
People leave the system not taking survey	1849
Registration Station Utilization	0.8251
Survey Station Utilization	0.9417
Registration Volunteers Utilization	0.1933
Survey Volunteers Utilization	0.5153

Basic results are listed above and more performance indexes will be introduced in the next section.

5. Optimization

5.1. Major indexes

We use the following four as performance indexes:

- "Ratio of leaving directly" and "Ratio of finishing the survey", we want the first index as small as possible and the second index as larger as possible. In this way, we could have more people to attend the career fair and finish the post survey.
- "Average processing time if not taking survey" is the average time waiting and transferring time in the queue for people who do not take the survey. In this module we want this value as small as possible. By intuition it is understandable that people do not want to wait for long time so a small number is better.
- "Average processing time if taking survey" is the average time waiting and transferring time in the queue for people who take the survey. In this module we want this value as small as possible. The reason is the same as the above one.

"Average time in Career Fair" is the average time a person spends for interviewing companies in the career fair. This does include people who leave directly. We will **NOT** optimize on this value.

Output	Average
Average processing time if not taking survey	19.7992
Average processing time if taking survey	16.8085
Average time in Career fair	35.0347
Ratio of fnishing survey	0.2406
Ratio of leaving directly	0.1567

Four Optimization Direction

5.2. Optimization setup

Using OptQuest (built-in application with Arena) to generate the result, we first define the range for the four inputs that might be modified for getting the optimized results.

They are the number of volunteers for directing students to the registration table, the number of registration tables, the number of volunteers for inviting students for post surveys and the post-survey tables.

		Controls Summary						
Includ ▽	Category	Control	Element Type	Type	Low Bound	Suggested Value	High Bound	Step	Description
✔	Resources	Registration Station	Resource	Integer	4	5	10	1	Registration stations
✔	User Specified	Registration Volunteer Number	Variable	Integer	3	4	6	1	Volunteers for directing people to registration station
✔	Resources	Survey station	Resource	Integer	4	5	8	1	Survey Station
✔	User Specified	Survey Volunteer Number	Variable	Integer	1	2	4	1	volunteers for survey

- The number of volunteers for directing students to the registration table: 3 to 6
- The number of registration tables: 4 to 10
- The number of volunteers for survey station: 4 to 8
- The number of survey volunteers: 1 to 4

5.3. Optimization alternative 1

5.3.1. Setup

From the result we get from Section 4. We could observe that the average time for waiting/transferring is ok. However, the ratio of finishing survey is not high, and the ratio of people who leave directly might be further optimized.

Inputs	Constraints	Optimization on
Volunteers for directing people	Average processing time	Ratio of leaving directly -> as low as possible
Volunteers for inviting to survey	Ratio of filling out the survey	
Registration table		
Survey Station		

We make the following three constraints for our optimization procedure:

		Constraints Summary		
Included	Name ▽	Type	Description	Expression
✔	processing time if not taking survey	NonLinear	processing time for people who do not take the survey	[Average processing time if not taking survey] <= 60
✔	processing time for people taking survey	NonLinear	processing time for people who take survey	[Average processing time if taking survey] < 60
✔	limit on finishing survey	NonLinear	the ratio of finishing the survey	[Ratio of fnishing survey] > 0.4

The average processing time (excluding the time for interviewing companies and fill out the survey) should be fewer than 60 minutes.
The ratio of students who fill out the survey should be bigger than 0.4.

		Objectives Summary			
Select	Name	Linear	Goal	Description	Expression
☐	processing time not taking survey	NonLinear	Minimize		[Average processing time if not taking survey]
☐	processing time taking survey	NonLinear	Minimize		[Average processing time if taking survey]
☐	ratiol of survey	NonLinear	Maximize		[Ratio of fnishing survey]
✔	ratio of leaving directly	NonLinear	Minimize		[Ratio of leaving directly]

The objective is to get the minimized ratio of leaving directly. This purpose is straightforward as the career fair is to help more students to extend their opportunities for employment. If the student decides to leave directly due to the long waiting queue, it is not good at all.

5.3.2. Optimization results for alternative 1

We run 100 rounds for simulation and we use advanced refine function to get the following results.

Simulation	Original Objective	New Objective	Replications	Status
Replication Summary				
9	0.186388	0.188017606875	8	Feasible
85	0.186388	0.188501802729	8	Feasible
106	0.187882	0.190732451385	8	Feasible
75	0.191135	0.191531834319	8	Feasible
81	0.191711	0.192249318794	8	Feasible
13	0.195524	0.190076397476	8	Feasible
46	0.183402	0.185188689883	8	Infeasible
104	0.183402	0.185454073418	8	Infeasible
54	0.193188	0.193840358981	8	Infeasible
44	0.189025	0.189391906023	8	Infeasible
83	0.189025	0.190068895353	8	Infeasible
88	0.192673	0.190883667312	8	Infeasible
32	0.000000	0	8	Infeasible
39	0.000000	0	8	Infeasible
86	0.150704	0.159186614716	8	Infeasible
28	0.000000	0	8	Infeasible
49	0.000000	8.119519324455	8	Infeasible
84	0.022342	0.019066750112	8	Infeasible
14	0.015973	0.021514285978	8	Infeasible
87	0.098962	0.100631037406	8	Infeasible
18	0.000000	0	8	Infeasible
71	0.071559	0.072746307365	8	Infeasible
29	0.000000	0	8	Infeasible
6	0.000000	0	8	Infeasible
100	0.153813	0.151493225051	8	Infeasible

Simulation result 9 could fulfil the constraints we set up for our model and could return the lowest ratio of leaving directly based on the constraints.

Constraint Name	Type	Status	Left Side	Operator	Right Side
Constraint Summary					
processing time if not taking survey	Non Linear	Feasible	51.216932	<=	60.000000
processing time for people taking survey	Non Linear	Feasible	48.406347	<=	60.000000
limit on finishing survey	Non Linear	Feasible	0.438190	>=	0.400000

Ratio of leaving directly: 0.186387984398693
Registration Station: 4
Registration Volunteer Number: 6
Survey station: 8
Survey Volunteer Number: 1

5.4. Optimization alternative 2

5.4.1. Setup

From alternative 1 we could notice set a constraints to have at least 0.4 as the ratio of filling out the survey. Actually sometimes the survey is only used to collect opinions and is not that important so we could use online survey or other methods to achieve the same result. So now we start to ignore the importance of the ratio of filling the survey but to put some attention of volunteers' utilization. As we notice the volunteer utilization is relative low in section4, we want to utilize the volunteer utilization to a reasonable level. We now still keep the interest on the ratio of leaving directly.

| Registration Volunteers Utilization | 0.1933 |
| Survey Volunteers Utilization | 0.5153 |

We could notice the Registration volunteer utilization is only 0.1933.

Inputs	Constraints	Optimization on
Volunteers for directing people	Average processing time	Ratio of leaving directly -> as low as possible
Volunteers for inviting to survey	The utilization of volunteers	
Registration table		
Survey Station		

We make the following three constraints for our optimization procedure:

Constraints Summary

Name	Type	Description	Expression
processing time for people taking survey	NonLinear	processing time for people who take survey	[Average processing time if taking survey] < 40
processing time if not taking survey	NonLinear	processing time for people who do not take the survey	[Average processing time if not taking survey] < 40
volunteers utilization	NonLinear	the utilization of volunteers	([Registration Volunteers.Utilization] - 0.5) * ([Survey Volunteers.Utilization] - 0.5) > 0

The average processing time (excluding the time for interviewing companies and fill out the survey) should be fewer than 40 minutes.
The utilization of volunteer should be larger than 0.5.

Objectives Summary

Select	Name	Linear	Goal	Description	Expression
☐	processing time not taking survey	NonLinear	Minimize		[Average processing time if not taking survey]
☐	processing time taking survey	NonLinear	Minimize		[Average processing time if taking survey]
☐	ratiol of survey	NonLinear	Maximize		[Ratio of fnishing survey]
☑	ratio of leaving directly	NonLinear	Minimize		[Ratio of leaving directly]

The objective is to get the minimized ratio of leaving directly. This purpose is straightforward as the career fair is to help more students to extend their opportunities for employment. If the student decides to leave directly due to the long waiting queue, it is not good at all.

5.4.2. Optimization results for alternative 2

We run 100 rounds for simulation and we use advanced refine function to get the following results.

	Select	Simulation	Objective Value	Status	Registration Station	Registration Volunteer Number	Survey station	Survey Volunteer Number	
▶	✔	6	0.000000	Feasible	10	6	8	4	
	✔	8	0.000000	Feasible	9	5	7	3	
	✔	11	0.000000	Feasible	10	3	5	3	
	✔	16	0.000000	Feasible	10	5	4	3	
	✔	18	0.000000	Feasible	10	3	8	3	
	✔	21	0.000000	Feasible	10	3	7	3	
	✔	22	0.000000	Feasible	10	4	4	3	
	✔	23	0.000000	Feasible	10	4	8	3	
	✔	24	0.000000	Feasible	10	5	5	3	
	✔	25	0.000000	Feasible	10	3	6	3	
	✔	26	0.000000	Feasible	10	4	5	3	
	✔	28	0.000000	Feasible	10	4	6	3	
	✔	35	0.000000	Feasible	10	3	4	1	
	✔	39	0.000000	Feasible	9	6	8	1	
	✔	42	0.000000	Feasible	10	3	4	3	
	✔	43	0.000000	Feasible	10	6	4	4	
	✔	45	0.000000	Feasible	10	3	4	4	
	✔	46	0.000000	Feasible	10	5	4	4	
	✔	47	0.000000	Feasible	10	4	4	4	
	✔	61	0.000000	Feasible	10	3	8	4	

More than one option could lead to the best result so this is an indication that we can have more investigations on the result. I start the third alternative and ignore the alternative 2 result.

5.5. Optimization Alternative 3

5.5.1. Setup

From alternative 2 I could see it is possible to achieve zero ratio of leaving directly through a lot of combinations. So now I want to achieve zero ratio of leaving directly and at the same time to enhance the ratio of filling out the survey. So now the index we want to optimize is the ratio of filling the survey.

Inputs	Constraints	Optimization on
Volunteers for directing people	Average processing time	Ratio of filling out the survey -> as high as possible
Volunteers for inviting to survey	The ratio of leaving directly	
Registration table	The utilization of volunteers	
Survey Station		

We make the following four constraints for our optimization procedure:

Name	Type	Description	Expression
processing time for people taking survey	NonLinear	processing time for people who take survey	[Average processing time if taking survey] < 40
processing time if not taking survey	NonLinear	processing time for people who do not take the survey	[Average processing time if not taking survey] < 40
volunteers utilization	NonLinear	the utilization of volunteers	([Registration Volunteers.Utilization] - 0.5) * ([Survey Volunteers.Utilizatio
Ratio of leaving directly	NonLinear	keep this zero	[Ratio of leaving directly] == 0

The most obvious difference as the alternative 2 is here we put Ratio of leaving directly == 0 as a constraint.

Objectives Summary					
Select	Name	Linear	Goal	Description	Expression
☐	processing time not taking survey	NonLinear	Minimize		[Average processing time if not taking survey]
☐	processing time taking survey	NonLinear	Minimize		[Average processing time if taking survey]
☐	ratio of leaving directly	NonLinear	Minimize		[Ratio of leaving directly]
☑	ratiol of survey	NonLinear	Maximize		[Ratio of fnishing survey]

Now the objective is to have as high ratio of survey as possible. Please notice in this condition we also could promise the ratio of leaving directly is zero.

5.5.2. Results

Through advanced optimization, we have the following rank.

Rank and Select Summary					
Simulation	Status	Feasibility	Original Objective	Current Objective	Replications
32	Eliminated	Feasible	0.380582	0.377395	13
20	Eliminated	Feasible	0.378143	0.377891	13
18	Eliminated	Feasible	0.376153	0.375157	13
6	Eliminated	Feasible	0.375420	0.375271	13
63	Eliminated	Feasible	0.375058	0.376175	13
25	Eliminated	Feasible	0.373998	0.376659	13
23	Eliminated	Feasible	0.373001	0.376740	13
57	Eliminated	Feasible	0.372589	0.369801	13
8	Eliminated	Feasible	0.333851	0.332309	13
97	Eliminated	Feasible	0.330091	0.329954	13
88	Eliminated	Feasible	0.295413	0.291777	11
91	Eliminated	Feasible	0.293588	0.293588	3
69	Eliminated	Feasible	0.291325	0.290723	13
11	Eliminated	Feasible	0.247485	0.246344	11
93	Eliminated	Feasible	0.243720	0.242724	9
77	Eliminated	Feasible	0.201535	0.201803	4
16	Eliminated	Feasible	0.200699	0.200505	7
98	Eliminated	Feasible	0.200616	0.199968	5
64	Eliminated	Feasible	0.200568	0.199868	8
54	Eliminated	Infeasible	0.369597	0.373470	13
24	Eliminated	Infeasible	0.377954	0.375881	13
10	Eliminated	Infeasible	0.369700	0.367617	13
4	Eliminated	Infeasible	0.369253	0.377534	13
89	Eliminated	Infeasible	0.292219	0.289114	11
94	Eliminated	Infeasible	0.204257	0.204257	3

So simulation combination 32 is the best one with 0.377395 as the ratio of filling out the survey and 0 ratio of leaving directly.

Registration Station: 9

Registration Volunteer Number: 3

Survey station: 8

Survey Volunteer Number: 4

6. Suggestion Based On the Optimization

6.1. Alternative 1 discussion

To sum up, alternative 1 is a possible enhancement is to use the following arrangement:

	Original	New	Enhancement
Registration Station	5	4	N/A
Registration Volunteer Number	4	6	
Survey station	5	8	
Survey Volunteer Number	2	1	
Processing time not taking survey	19.80 minutes	51.22 minutes	No
Processing time taking survey	16.81 minutes	48.41 minutes	No
Ratio of taking survey	0.2466	0.4382	Yes
Ratio of leaving directly	0.1567	0.1863	No

Based on this alternative, we could have fewer Registration Station and fewer Volunteers for Surveys, but more volunteers for directing people to the registration table and more survey stations.

The good part is the ratio of taking survey is significantly increased by 43.82% and the ratio of people leaving directly roughly keeps at the same level (using 0.1863 compared with 0.1567). On the other hand, the time used in other procedures is highly increased from 19.80 minutes to 51.22 minutes, and 16.81 minutes to 48.41 minutes respectively.

6.2. Alternative 2 discussion

Alternative is just an intermediate result. We make THIS trial to understand more possibilities so we do not discuss it here.

6.3. Alternative 3 discussion

To sum up, alternative is a more reasonable optimization result based on our observation in alternative 2.

	Original	New	Enhancement
Registration Station	5	9	
Registration Volunteer Number	4	3	
Survey station	5	8	
Survey Volunteer Number	2	4	
Processing time not taking survey	19.80 minutes	1.517 minutes	Yes
Processing time taking survey	16.81 minutes	1.058 minutes	Yes
Ratio of taking survey	0.2466	0.3765	Yes
Ratio of leaving directly	0.1567	0	Yes

According to the results we could see finally all four performance indexes are improved. Especially for the "Ratio of leaving directly" which decreased to 0 which means nobody would leave directly because of the long waiting time. The only thing we need to be notified is we will need to use almost two times Registration Stations and Survey Stations. But overall, this setup should be a good choice to have low waiting time, reasonable rate of taking survey and low rate of leaving directly.