IE 551: Project 2

SOFTWARE MADE PERSONAL - CALL CENTER SIMULATION

Date: 04/07/2020
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Subject: Find the optimal number of cross-trained operators working in a call center without affecting the system efficiency by comparing the wait times of incoming calls in current system with the proposed system.

OBJECTIVE:
To determine the optimal number of cross-trained operators working at SMP by comparing the current system of individual departments having specific operators to the proposed system of having cross-trained operators using Queuing tools and Queuing theory.

EXECUTIVE SUMMARY:
Considering that we expect the same level or even better performance from the proposed system as compared to the current system, **we recommend having 7 operators and 2 technicians** to handle daily operations at a better efficiency rate. The average wait time for a call is **1.68 mins** as compared to the wait times of current system; 2.46 mins for Financial Products, 2.08 mins for Productivity Products and 8.72 mins for Contact Management Products.

SOFTWARE USED:
To obtain the best fit distribution for our given data of Incoming calls per day, service time of operators and technicians, we use Arena's 'Input Analyzer Tool'. To simulate the SMP environment, we use Arena Modeling Software.

EXPERIMENTAL DESIGN AND ANALYSIS:
We use queuing tools to approximate the wait time in queues and service times of operators.

1. **Determining the optimal number of replications for simulation:**
   - Choose an initial small number of replications (say R = 10) to obtain the estimates of total calls processed per day and average wait times in process queues.
   - The Arena Category Overview Report gives us the average values for various variables along with the respective halfwidths (H)
   - We use the formula: $R = Ro * (\frac{H}{e})_2$ where, H = Halfwidth for 95% Confidence Interval, e = error, R_0 = Initial number of Replications, R = Desired number of replications.
   - The desired level of error for our model is decided to be set to 1 min based on our judgment of call times.
   - We assume that consideration of the maximum halfwidth value will account for the halfwidth values for other queues too.
   - Number of replications used in our model: 300

2. **Input Modelling**
   - We assume a Poisson arrival process for incoming calls and exponential inter-arrival times based on given data for number of calls processed per day. The maximum time an operator spends per call in 9 minutes.
   - The system operates from 8am to 4pm (8hrs). No new entities enter the system post hours of operation and the system shuts down only after the last entity in system is out. Arena allows us to build this terminating condition in Run setup which is: **TNOW >= 480 && Total WIP == 0**, where TNOW is the total time for which the system operates, 480 minutes since it should run even after hours of operation, Total WIP is the total number of entities in system; set to 0 since we want all the calls to be processed before shutting the operation.

- Arena allows us to animate the resources and entities used in system. We use a telephone picture to represent calls in current system which changes to colored balls as per departments, animated people can be seen as idle and busy operators/technicians in both current and proposed system.

Below table summarizes the process and their best fit distribution along with the assumptions:

Process	**Best-fit distribution**
Incoming calls arrival rate	Random(Expo) - 0.9937 mins
Delay for selecting department in current system	TRIANG(6, 18, 30) seconds
Service time of operators in current system	TRIANG(2, 4, 9) mins
Service time of technicians in current system	1 + ERLA(10.1, 3) mins
Delay in call connecting in proposed system	TRIANG(6, 18, 30) seconds
Service time of operators in proposed system (10% increment in current values)	TRIANG(2.2, 4.4, 9.9) mins

3. Determining and estimating the performance measures

- Arena does not provide the values for all desired variables.
- We use the 'variable spreadsheet' feature from 'Basic Process Panel' to define '**CallsperArrival**' (set to initial value 1), '**MaxCalls**' (set to a very high number) and 'Total WIP' (total work-in-process time, no initial set value).
- Secondly, we use the '**Statistics Spreadsheet**' feature from 'Advanced Process Panel' to extract 'Average Wait times' and 'Number of calls processed per day' data from each replication.
- **Arena allows us to save user specified variables in a spreadsheet and exports it to our specified location in computer used**.
- These values help us determine the point estimate and the confidence interval for each chosen performance measure.

The below tables summarize the performance measures chosen for both '**Proposed System Efficiency**' and '**Customer Satisfaction**' along with the estimates obtained from 'Category Overview Report' of Arena and extracted excel files.

Note: Resources used are 7 cross-trained operators and 2 technicians

Performance measure	**System Efficiency (No. of calls processed per day**	**Customer satisfaction (Wait times in call queue)**
Mean	On an average, **483 calls** are processed on a single working day	The average wait time in queue for call processing is **1.68 minutes**
Probability	There is just **8% probability** that less than 450 calls would be processed in a day	There is just **2% probability** that the average wait time for the call processing would be more than 3 mins
Quantile	There is **80% probability** that the number of calls processed in a day would be **at least 500**.	There is **80% probability** that the average wait time in the queue would be **less than 1.73 mins.**

Note: Resources used are 6 cross-trained operators and 2 technicians

Performance measure	**System Efficiency (No. of calls processed per day**	**Customer satisfaction (Wait times in call queue)**
Mean	On an average, **485 calls** are processed on a single working day	The average wait time in queue for call processing is **6.67 minutes**
Probability	There is just **6% probability** that less than 450 calls would be processed in a day	There is just **15% probability** that the average wait time for the call processing would be more than 10 mins

Quantile	There is **80% probability** that the number of calls processed in a day would be at **least 502.**	There is **80% probability** that the average wait time in the queue would be **less than 7.92 mins.**

In addition, we ran the proposed system model with 5 operators and the average wait time increased to **38.36 mins**. which is not acceptable.

- To compute the confidence intervals (C.I.) for mean values, we refer the category overview report and use average value for point estimate and the corresponding halfwidth values.
- For probability measures, we count the values from excel sheet and obtain the point estimate. The below mentioned formula is used to compute the C.I.

  $p \pm Z - statistic * \sqrt{\frac{p(1-p)}{R-1}}$

  where, p = point estimate; R = No. of replications; Z = 1.96 for α = 0.05
- For quantiles, we find the point estimate by multiplying probability by number of replications. Here, point estimate for 80% probability is 0.8*300 = 240$_{th}$ value in the sorted excel sheet. We use the above-mentioned formula to find upper and lower limits of probability values. These values multiplied by the number of replications give us the index of lower and upper limit values. Here, we have the 225$_{th}$ and 252$_{nd}$ values and lower and upper confidence limits respectively.

The below tables summarize the performance measure values and the respective C.I. for proposed system with 7 cross-trained operators and 2 technicians.

Variable	Performance measure	Point estimate	95% Confidence Interval (C.I.)
Number of calls processed in a day	Mean	483	[480.48, 485.48]
	Probability	0.08	[0.05, 0.11]
	Quantile	500	[497, 505]
Average wait time in queue	Mean	1.68	[1.58, 1.78]
	Probability	0.02	[0.005, 0.035]
	Quantile	1.73	[1.58, 1.85]

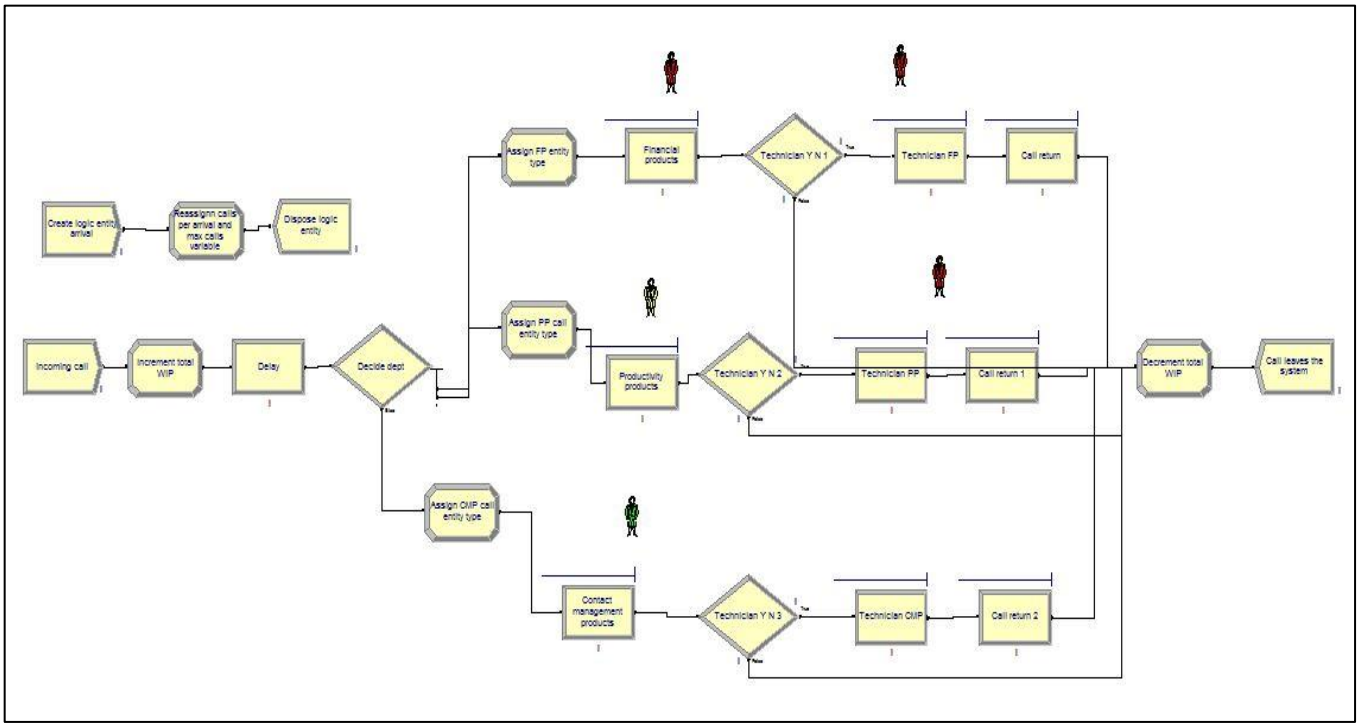
RESULTS: The average wait time in queue increases from 1.68 mins to 6.67 mins when we reduce the number of operators to 6 from 7 and is not recommended. The proposed system with same number of operators as before will give better customer satisfaction in terms of queue wait times. The initial approximations from queuing tools suggested that the number of operators could be reduced to 6 without affecting the system performance, which contradicts the system simulation results.

SHORTCOMINGS

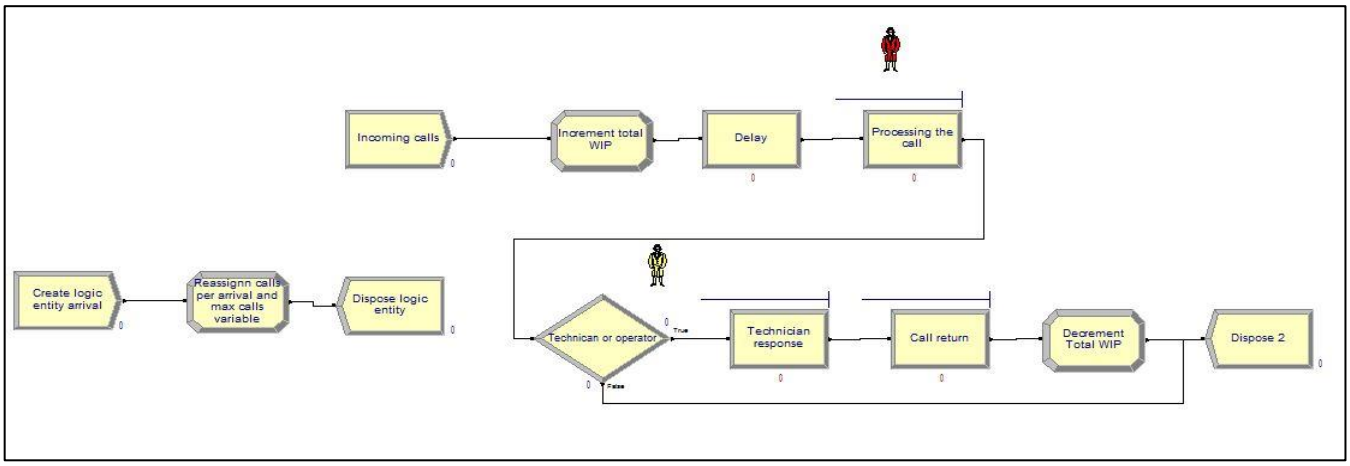
- The distribution obtained for number of incoming calls, service times of operators and technicians is obtained from a limited number of sample points. We could use bigger data to obtain closest possible distribution for the collected data.
- We consider a tolerance of 1 min while calculating the ideal number of replications, which could be further reduced.
- We assume that all the dialed calls connect which is not a realistic scenario.

APPENDIX

Current system:



Proposed system:



Input modeling:

- The data for number of incoming calls is given. We use ‘Arena Input Analyzer’ tool to find the best fit distribution.
- We get the mean number of calls as 483. Since in queuing theory it is better to consider arrival process as Poisson, we do so and convert 483 calls per day to 8*60/483 minutes.
- Thus, we have Random(Expo) with mean value of 0.9937 minutes.

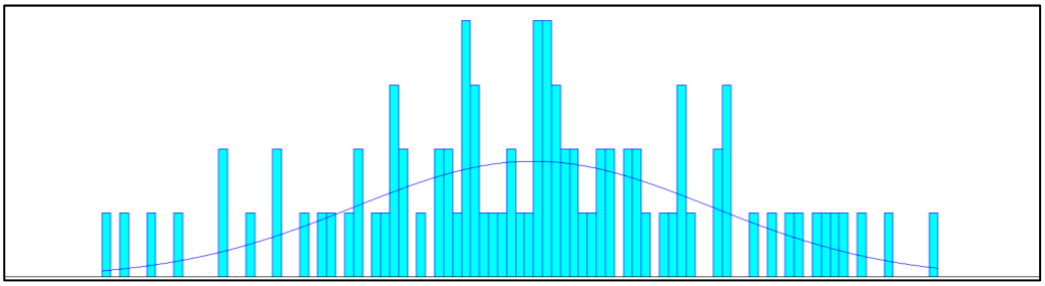


Figure 1: Best fit distribution as obtained from Arena Input Analyzer for incoming calls data

In case of the service times of technicians, we get:
1 + ERLA(10.1, 3) minutes

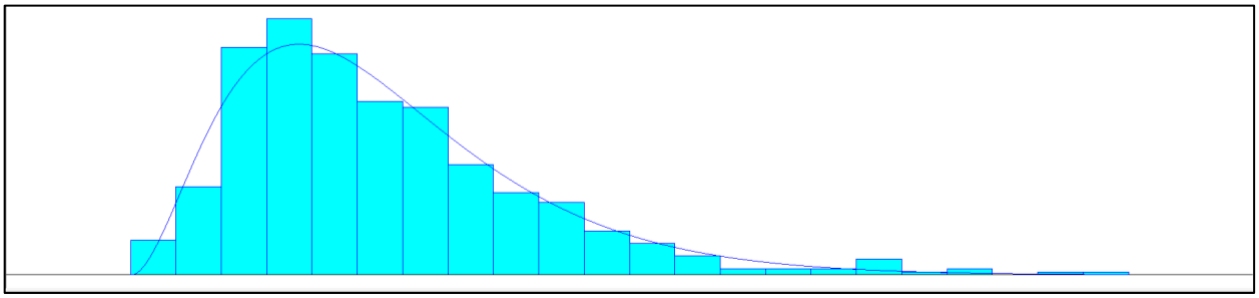


Figure 2: Best fit distribution as obtained from Arena Input Analyzer for Technician service times

Run Setup:
Number of replications: 300 – Deciding process described in main report
Replication length: Infinite – Since we terminate the process using a terminating condition
Number of hours in a day: 24
Base time units – Minutes – We get the output values in minutes on report
No warm period is set.
Terminating condition: TNOW >= 480 && Total WIP == 0