

Department of Industrial Engineering and  
Operations Research, UC Berkeley

IEOR 151 Project Report

Hardwood Flooring Service  
Operation and Warehouse Location  
Analysis

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Prepared for:

Prof. Max Shen

## Background:

T&T Floors is a full service company specializing in hardwood flooring installation, repair as well as refinishing. The company has been serving the Bay Area since 1989 and building a decent reputation in the San Francisco and East Bay areas. T&T Floors has a showroom and a warehouse for its working vehicles; both are located in Oakland, right next to the city of Alameda.

## Hardwood flooring service overview:

Hardwood flooring service industry in the Bay Area has a competitive market. Generally, customers (either a housing development or a private home owner) contact different flooring companies to request proposals. Then, these companies will have to send their estimators to the job site to measure the square footage, the layout and the difficulty of the job in order to give the customer a bid.

The customer will then decide to go with one company and reject all others. This decision is based on many different factors such as pricing, service level reputation, promised waiting time, etc...

Once the customer chooses a company, what happens next will depend on the type of the jobs to be performed. The following event graph describes different routings of the three job types through the system in T&T Floors: Pre-finished Installation, Un-finished Installation and Refinishing.

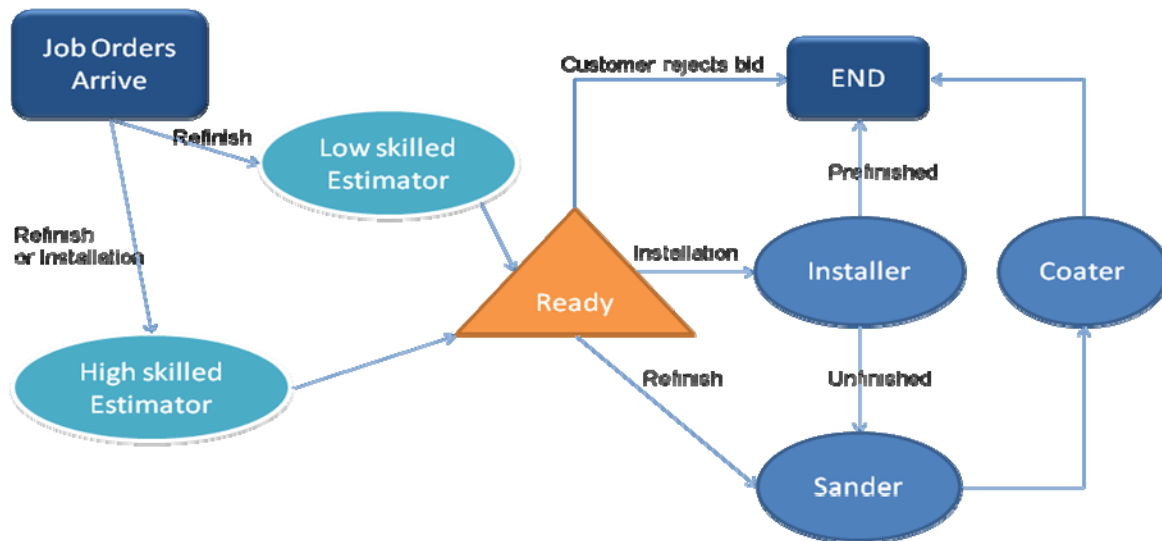


Figure 1 Event graph of hardwood flooring service operation

If the size of a job doesn't allow the workers to finish within a day, the company will have to send them back and forth the next day to complete it. The coating process is the most time consuming because they have to wait a day for the coating to dry before applying the next one; and a standard floor job requires three coats. Generally, a regular floor job (600 square feet) takes two days to install, one day for sanding and three days for coating.

## Problem identification:

As illustrated in the diagram above, to complete a job, T&T Floors needs to send their workers from the warehouse to the job site and back not just one but multiple times. We believe that minimizing the average travel distance is a good objective for this project and that the resulting solution will benefit the company in many ways.

## Problem Analysis:

To determine the optimal warehouse location, we first need to form a network of demand population and the distribution of that demand.

### 1. Demand Population Network:

Starting off with a map of the bay area, we divide it into 9 different zones. Each zone is marked by its major city abbreviation, as follows:

SR: San Rafael,  
Mill Valley, Sausalito, Fairfax,  
Novato, Tiburon.

VI: Vallejo,  
Benicia, Rodeo, Hercules,  
Martinez.

SF: San Francisco,  
Daly City, Brisbane, San  
Bruno, South San Francisco.

Ok: Oakland,  
Berkeley, Alameda, Piedmont,  
Albany, El Cerrito, Richmond.

WC: Walnut Creek,  
Lafayette, Orinda, Moraga,  
Concord, Alamo, Danville.

SM: San Mateo,  
Burlingame, Millbrae, Foster  
City, Redwood City, Palo Alto.

Hy: Hayward,  
Castro Valley, Union City,  
Fremont, San Lorenzo.

Db: Dublin,  
Pleasanton, San Ramon,  
Livermore.

SJ: San Jose,  
Mountain View, Sunnyvale,  
Santa Clara, Milpitas.



Figure 2 Network map of the Bay Area

The arcs are the representation of the shortest paths to get from one node (or zone) to another following the major freeways.

## 2. Estimation of Demand Distribution and the Coordinate System:

T&T Floors organizes the records of job orders for each city in the Bay Area; and data from the last five years were available for our research. Having access to this valuable resource, we were able to generate an estimation of the regional demand distribution:

For each of the 9 zones, the summation of the annual square footage from each of its city gives the zone's total yearly demand. Realizing that the hardwood flooring service demand is quite stable during the seasons, we decided to employ the exponential smoothing forecast method to come up with the demand estimation for the year 2008.

The unit of this estimation here is in thousands of square feet per year.

Our next step in this location problem is to assign an arbitrary coordinate system to the area of interest and determine the location of each zone in the system, as follows:

SR(2.1,8.0); VI(5.5,8.3); SF(1.4,4.3);  
 Ok(3.5,4.0); WC(6.1,4.5); SM(1.3,1.2);  
 Hy(4.0,1.0); Db(6.2,1.3); SJ(3.9,3.8)

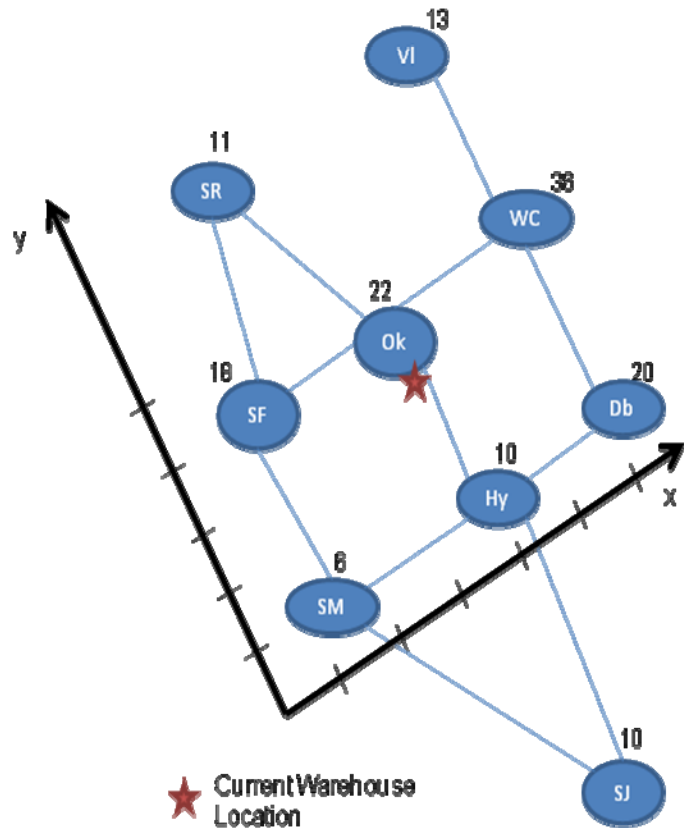


Figure 3 Demand distribution and coordinate system

## Solutions:

### 1. Solution to the warehouse location problem:

Considering the layout of the nodes and the shortest paths to get from one node to another, we believe that the Metropolitan distance model is the most appropriate way to solve this problem. Indeed, the solution is quite simple:

Half of the total demand can be easily calculated,  $\frac{(10+6+10+20+18+22+36+11+13)}{2} = 73$

The median of the population (4.3, 4.0) is the optimal location, which is relatively close to the current warehouse location.

### 2. Solution for the future:

During the process of forecasting demands for each zone, we realized a quick growth rate in number of job orders coming from the East side of the Bay. Apparently, the housing development has been very active in these areas along the highway 680, especially Walnut Creek, Danville and San Ramon, for the last 2-3 years. At this rate, it is very likely that the solution to the aforementioned problem will be shifting from Oakland towards the East in a short time; and soon enough, the optimal warehouse location for T&T Floors will be in Walnut Creek. However, the company is against the idea of having the warehouse too far away from San Francisco. They feel that moving away from this major market will affect its customer behaviors and eventually hurt their market share. Therefore, T&T Floors' managers have stated that they will not consider moving the current warehouse to anywhere further than west bound of Orinda city.

### 3. Verifying the solutions:

To prove that moving the warehouse closer to the 680 freeway will benefit the company, we decided to use a simulation model, which we built for IEOR 131 last semester (with the same company), to perform a cost-benefit analysis. The new location of the warehouse in Orinda and the growing demands in the area were hard-coded in the model (please see Appendix A for the detail of the simulation model).

The simulations return a remarkable difference between the two locations of warehouse in terms of miles travel per square foot, labor hour per square foot, and average customer waiting time per square foot.

### 4. Projected benefits:

The following results were measured in the simulation year 2009, when our forecast determines that the median of the population has moved to Walnut Creek:

<b>Simulation results comparison, simulation year 2009</b>		
<b>Annual</b>	<b>Warehouse located in Oakland</b>	<b>Warehouse located in Orinda</b>
<b>Miles travel per square foot</b>	<b>0.73</b>	<b>0.60</b>
<b>Labor hour per square foot</b>	<b>0.0501</b>	<b>0.0472</b>
<b>Customer wait time per square foot (days)</b>	<b>.081</b>	<b>.080</b>

**Table 1 Simulation results comparison, simulation year 2009**

With the total demand forecast of 150,000 square feet in the year 2009 and the new warehouse location in Orinda, the first two criteria will save about \$30,000 in labor, gas, vehicle and tool maintenance and insurance cost. At the same time, customer satisfaction will receive a big boost with essentially about half a day cut off in average waiting time for a regular floor job.

### **Recommendations:**

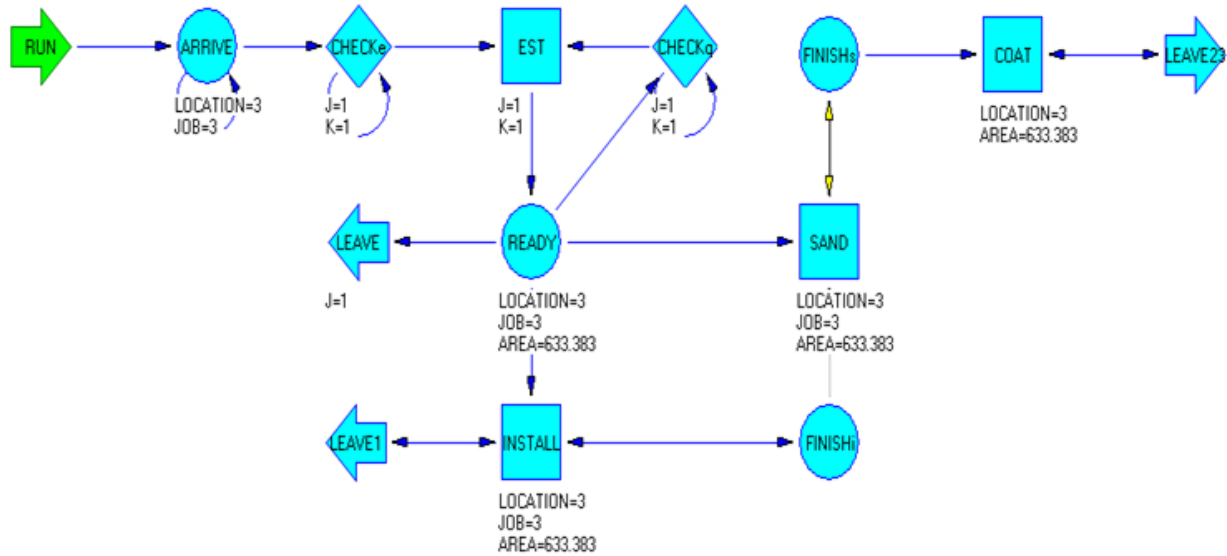
We believe that T&T Floors, being a full service company, will not have much trouble moving their office and warehouse to a new location. First of all, they will not have to deal with any inventory. Second, all of the job orders come from telephone, fax and internet communication. Therefore, virtually there is no change or delay in the company's operations. Perhaps, the only thing that might concern the company is to give its employees some time to settle down with the new place.

Based on the results of our analysis and simulation, implementing the solution of this study will greatly benefit the company in many ways, now and in the long run. Therefore, we recommend T&T Floors to make this move as soon as possible.

## Appendix A: Hardwood Floor Business Simulation

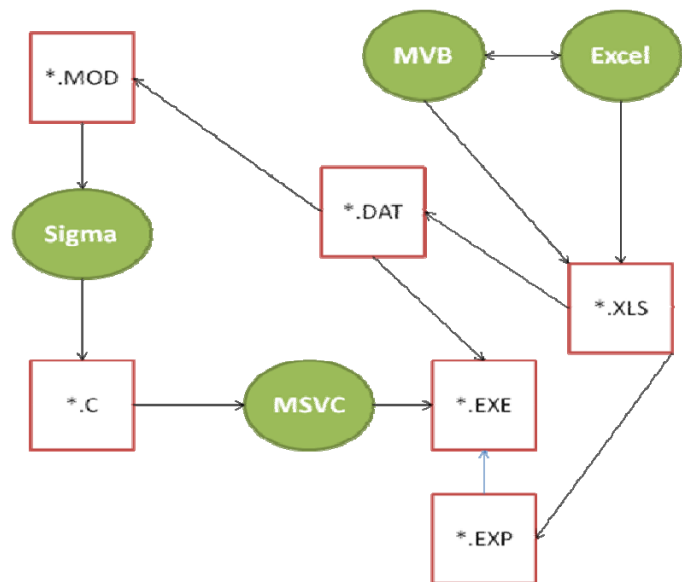
### 1. Sigma model:

The following Sigma model describes the exact event graph as seen in figure 1.



### 2. Software Package:

Sigma framework is an analytically powerful piece of software. The model was then translated to Microsoft Visual C to create an executable stand-alone program. In the mean time, the friendly user interface was achieved by the versatility of Microsoft Excel in conjunction with Microsoft Visual Basics. This combination of the Microsoft software will also enable the simulation to produce meaningful graphical output, precisely representing the project's outcomes even before it starts.




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*Professor Shen: We have sent you a complete report of this simulation. Please refer to that electronic document for detail.*

## Appendix B: Thank you letter:



BANZAI

*Simulation Dynamics*

Banzai Team  
3113 Etchevery, Hearst Ave.  
Berkeley, CA 94706  
December 10, 2006

Yohan Gourcuff  
President  
T&T Floors, Inc.  
421 23<sup>rd</sup> Ave.  
Oakland, CA 94606

Dear Yohan Gourcuff:

I wanted to express my gratitude in allowing us to visit your company office and warehouse in Oakland. There are so many interesting and unique problems that the construction industry faces, especially as a service-oriented company. Tuan, my partner for this project, and I wanted to visit to find opportunities for hopefully applying principles and concepts that we have learned in our class on service operations design and analysis.

Fortunately, we found exactly that. Our visit brought to our realization the importance of studying real problems, along with difficulties inherent in them that do not necessarily come to surface in the classroom. It is our hope that we can bring to light – and ideally, give recommendations or solutions for – areas of potential problems in the firm's service operations. Our growing knowledge of service operations design, we believe, has provided us with the framework for viewing problems and potential problems within the industry, and we are just glad that you are allowing us to be a part of that. We wish you the best in all your future endeavors.

All the best,

*Karey Park*

Karey Park  
Project Engineer

Enc: (1)

## **Appendix C: What we learned from this project:**

Our team project with T&T Floors taught us, among other things, how to integrate our knowledge of various concepts and tools in providing an analysis for real, day-to-day, problems that the hardwood flooring service industry faces. To identify T&T Floors' problem in the first place, we had to peruse their demand data in order to accurately estimate the demand by region, and organize all of this into a coordinate system. Having an understanding of both the "traveling salesman" problem as well as location covering models, we were able to view this as a variation of a traveling problem, with an additional requirement of taking into account the growth rate of housing orders in certain cities around the Bay Area.

Given the nature of the services that T&T Floors provides, they naturally presented us with issues that were not exactly textbook problems. This meant that we had to extrapolate principles learned in class to apply them in a way that we were not accustomed to using. For example, while we had focused primarily on the problem formulation for location models, we had to use the Metropolitan distance model to determine the ideal location for their office and warehouse. Our modeling via simulation further pushed our ability to combine various concepts and tools.

Being a full-service company carries with it several additional responsibilities, not the least of which is the capacity to do more than one type of job. We also learned that full-service requires knowledge of when each type of job should be applied. Through our knowledge of service operations, we were glad to learn how these concepts make themselves applicable in the operations of a full-service industry such as T&T Floors.