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Engineering Large Event Catering Services

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Abstract. In the United States, catering services constitute about \$8.6 billion annually. The main objective in managing large catered events is centered around ensuring good customer satisfaction while minimizing food wastage. Achieving this management objective is challenging because of some of the key characteristics of such service systems such as long setup time, time-varying demand, and complex customer food preferences. Industry practice heavily relies on the experience of individuals with little use of model-driven decision-making for planning such events. This paper takes a service system engineering approach for event catering by developing an analytical framework for decision-making by event planners to determine kitchen capacity, temporary storage capacity for warmers, and staffing level for buffet service. The proposed model is distribution-free and provides intuitive visualization for decision-making. As a practical case study, the model is applied to a large catered event with an attendance of about 10,000 over three hours.

Keywords: event catering, food services, gastronomic services, buffet-style catering

1 Introduction

Event catering plays a vital role in creating memorable events. Researches have shown that the quality of food, the quality of services, and the fit for the event's atmosphere are essential for increasing satisfaction and creating a holistic experience for guests [1]. Good food experiences also attract attendees to participate in the events and increase customers' return intention in the future [2]. Therefore it is important to plan event catering as well as possible.

Food wastage is one of the main issues of event catering. Reports by FAO indicate that one-third of all food produced for human consumption is wasted [3, 4]. In particular, in developed countries, food services cause 14% of food wastage [4]. In the United States, catering services constitute about \$8.6 billion annually. Thus, event catering is a significant source of food wastage. Monteiro et al. studied the food wastage in event catering in higher education institutions in the UK and investigated the possible causes for food wastage [5]. They suggested that there is a need for planning tools to help inexperienced planners reduce wastage.

Recent efforts in modeling for catering services focus on linking food production with its transportation to the location where the event is held, with the main emphasis

on the freshness of the food when served. Farahani et al. introduced a heuristic method based on vehicle routing problems to help catering companies integrate the decision on both their short-term production and distribution plan [6]. Yağmur and Kesen developed a fast algorithm for joint production and distribution scheduling with perishable products [7]. Wu et al. studied the catering services for high-speed rail in China [8]. They developed a lot-sizing network optimization model to determine the location for producing foods and control the on-train inventories with capacity limits and time-varying demand.

To our best knowledge, there is no published work focusing on analytical models for decision-making for planning event catering. Such a model can help reduce reliance on the experience of individual planners and help improve customer service along with reductions in food wastage. This paper takes a service engineering approach for event catering by developing an analytical framework for decision-making by event planners to determine kitchen capacity, temporary storage capacity for warmers, and staffing level for buffet service. In section 2, the characteristics of large catering events are discussed. Section 3 presents the “distribution-free” analytical framework in detail. Also, a case study is used to demonstrate the framework. We conclude and discuss possible future work in section 4.

2 Characteristics of Large Event Catering

There are many types of event catering services. Its design depends on the event scale, venue types, or the types of food provided [5]. This research studies large buffet-type catering services which coordinate with kitchen operation in close proximity to the venue and provide hot food. There are three critical characteristics in these events: long setup, time-varying demand, and high food wastage.

2.1 Long Setup

A catering event is often less than three hours, but the planning time and preparation time are much longer than the event duration. During the event, the demand can be large range from a few hundred to several thousand and kitchen operations need to prepare enough food before the demand surge occurs. Therefore kitchen needs to have surge capacity planned for such operation, e.g., setup more grills or fryers along with corresponding staff members. This installed capacity can be reduced to some extent by preparing food ahead of time and storing it appropriately. For food items whose quality depends on their temperature, insulated boxes (bags) or food warmers would be needed for this temporary storage.

Therefore, determine the setup time, i.e., when kitchen operations commence, is crucial for event catering. For example, if the setup time is advanced to an earlier time, then kitchen operations can be slowed down with corresponding reductions in installed capacity but more storage capacity would be needed. Installed kitchen capacity may be constrained by venue-specific parameters such as space and utilities (e.g., maximum power that can be drawn).

2.2 Time-Varying Demand

An event catering demand profile can exhibit significant dynamics and swings depending on the timing of other activities in the event. For example, a huge surge of guests would join a lunch buffet if several sessions at a conference end simultaneously just before the lunch break resulting in a demand profile that is shown in **Fig. 1(a)**. If event catering is before an important activity then the demand profile could have a profile as shown in **Fig. 1 (b)** or (c). If the event catering is planned between two important activities, then the resulting profile could be as shown in **Fig. 1 (d)**.

It should be emphasized that the demand profile has a significant impact on decision-making for event planning. For example, the kitchen might need to start earlier and stop earlier if the demand profile is as **Fig. 1 (a)**. On the other hand, demand profiles like **Fig. 1 (b)**, (c), (d) do not impact the setup time significantly.

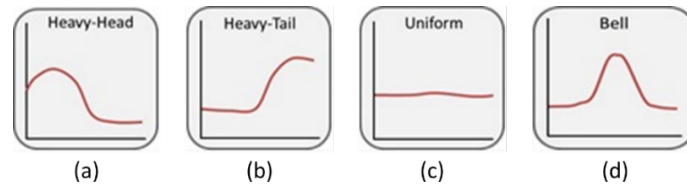


Fig. 1. Different Demand Profile

2.3 Customer Food Preference

Customer food preference is one of the essential factors for planning a good event catering. It determines how much food should be prepared. It should be considered when creating the menu, especially for hot food items, since most of these may be disposed of after the event if guests do not consume them. Good design of menu considering customer preference reduces the plate waste during event. However, customer food preference in event catering is largely unknown compared to restaurants that have recurring guests over several years of operation. Moreover, the food preference in event catering is influenced by many factors including weather, time, type of event, type of guests, and menu design [9]. One way to consider customer preference in planning is to estimate guest preference probabilities for each food item from some historical data.

In order to assist event planners in dealing with the challenges of long setup times, dynamic demand, and unknown food preferences, we propose an analytical model for decision-making through the context of a case study in the next section.

3 Analytical Model for Planning Event Catering: A Case Study

In this section, through a case study we propose a three-phase decision framework to plan event catering for a buffet-style catering with hot food. The framework shown in **Fig. 2** includes three phases: system analysis and design, kitchen and service capacity

synchronization, and detailed planning. The main objective of this planning is to synchronize kitchen capacity (e.g., number of grills), service capacity (e.g., number of buffet lines and employees). Consequently, the space of food capacity (e.g., number of warmer) and the kitchen operation time can be determined.

Phase I: System Analysis and Design.

In the first phase, some primary operational data should be collected: arrival profile of guests (see Fig. 1), kitchen cooking times, service times for each food item, and food preference. It should be noted that some food items such as bottled water, which does not seize the kitchen capacity, need not be considered in the plan.

Phase II: Kitchen & Service Synchronization.

In the second phase, the planner uses rough capacity planning to determine the overall kitchen capacity and overall service capacity with the demand profile predicted in Phase-I. With different kitchen capacity and service capacity decisions, kitchen operation time, max storage level, and max queue level of the event are computed. It could provide an intuitive visualization for decision-making.

Phase III: Detail Planning.

The last phase calculates pieces of kitchen equipment, the number of food lines, and the number of warmer required by the rough capacity planning in Phase-II.

3.1 Case Study Description

Penn State University serves the military and veteran community every year by giving special recognition to our service members, veterans, and their families by offering free admission to sporting events, including an annual tailgate party and tickets to football games. The tailgate party, attended by over 8,000 people, consisted of military appreciation, entertainment shows, and food catering. The layout is as shown in Fig. 2.

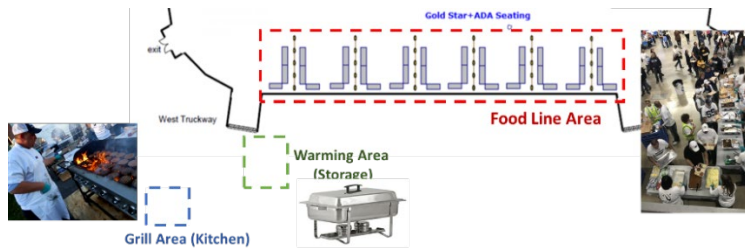


Fig. 2. Event Catering Layout

The tailgate is organized at a sports arena. Volunteers are stationed to direct the flow of people and to staff the food lines. The venue consists of two seating areas and L-shaped food lines containing nine servers each and two counters for dessert and drinks. All the food lines and dessert counters serve guests simultaneously. The kitchen is located outside of the main venue, where the food is prepared and brought to the food lines by volunteers. The cooked hot food is stored between the kitchen and the venue if food items in the food lines are sufficient.

3.2 Operation Analysis & Design

In the following case study, the data collected in the 2016 tailgate party is used. The event started from 2:00 pm to 6:00 pm, four hours in total.

Demand Analysis

In record, there were 8160 guests at the event. The event was right after the sports event, so a demand surge occurred in the first 20 minutes (**Fig. 3**). After the demand surge, the demand became smooth. Thus, we model the demand profile with two sections: rush hours and non-rush hours. In rush hours, the average demand rate was 120 guests/minute. On the other hand, during the non-rush hours, the average rate was 36 guests/minute. The average demand rate (D) during the event is 45.33 guests/minute.

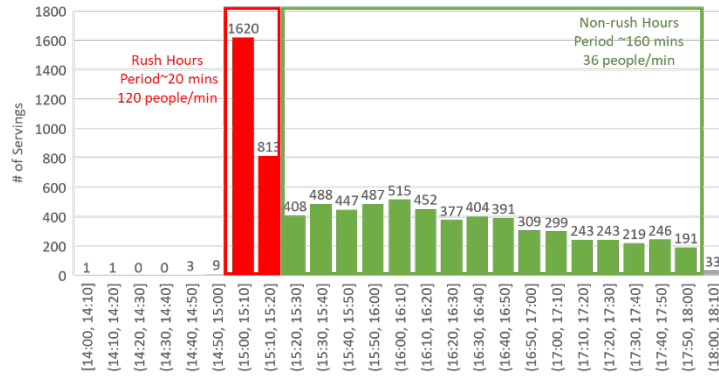


Fig. 3. Demand profile

Kitchen Operation Analysis.

All the hot foods produced by the kitchen were cooked by grills. The cook batch size, cook time for each batch are shown in **Table 1**. The unit cook rate of a grill (p), calculated by Eq. (1), is 2.50 servings/minute/grill. Also, the number of serving can be stored in a warmer for each item was also measured.

$$p = \left(\sum_i \frac{f(i) \cdot T_c(i)}{B(i)} \right)^{-1} \quad (1)$$

Table 1. Kitchen operation time analysis

Item	Burger	Hotdogs (S)	Hotdogs (L)	Chicken
Cook Batch Size $[B(i)]$ (servings/batch)	40	40	40	40
Cook Time $[T_c(i)]$ (minutes/batch)	12	8	10	10
Storage Vol. (servings/warmer)	12	12	12	12
Food preference $[f(i)]$ (%)	90%	70%	50%	85%

Food Service Analysis.

There were nine servers in each food line and the service times are in **Table 2**. Since the food line service is like an assembly line, the bottleneck server dominates the service rate. The bottleneck in this case is the Chicken station with a service time of 14.04 seconds/serving.

Table 2. Foodservice time analysis & food preference probabilities (*bottleneck)

Server	Plates	Bread	Burg- ers	Hotdog (S)	Hotdog (L)	Chicken*	Mac & Cheese	Beans	Salad
Proc. Time (secs)	6.61	9.01	8.49	9.19	7.35	14.04	7.73	8.39	7.18

3.3 Rough Capacity Planning

The rough capacity planning is to determine the overall kitchen cook rate (P) and the overall service rate (S), given a demand profile from section 3.2, using the sample path analysis [10]. Sample path analysis is “distribution-free” for studying queueing systems. Thus, the planning can be evaluated even only a few historical data exists. It considers the interaction between cumulative demand, cumulative service and provides a visualization tool for decision-making like **Fig. 4**. The analysis considered three steps. The first step is to decide the cumulative demand curve $D(t)$. In section 3.2, we construct the demand curve into two sections: rush and non-rush, thus the cumulative demand curve is a piece-wise increasing function shown in **Fig. 4 (a)**.

The second step, the cumulative production curve $P(t)$ is determined with three assumptions: (1) the kitchen should be closed before the end of the event, (2) the first guest should get served right after he arrives, and (3) the kitchen production rate keeps constant during the event. To avoid overproduction, which may cause food wastage, the cook start time (t_s) is,

$$t_s = \begin{cases} \left(\frac{D}{P} - 1\right)T, & \text{if } P < D \\ 0, & \text{if } P \geq D \end{cases} \quad (2)$$

where D is the average demand rate calculated in section 3.2; P is the overall kitchen production rate, the slope of $P(t)$; T is the length of event duration. In this step, the maximum storage level can be computed, which determines the number of warmer needed. For the scenario in **Fig. 4**, T is 3 hours (3pm to 6pm). If the designed production rate is 37 servings/minute, the cook start time is at least 40 minutes before the start of the event.

The final step is shown in **Fig. 4 (c)**. The service rate s is assumed to be constant during the event as well. However, the service rate is always dominated by production rate and demand rate. If the food cooked was not enough or no demand came, the server would not work. Thus, the cumulative service curve $S(t)$ cannot surpass the cumulative demand curve $D(t)$ and cumulative production curve $P(t)$.

$$S(t) = \min\{sl, P(t), D(t)\} \quad (3)$$

where l is the number of food lines designed. In this case, the number of food lines is 12, so the maximum service rate is 50.40 customers/minute. However, $S(t)=36$ after 4:56 p.m since the service rate is dominated by the demand rate.

In this step, the maximum number of guests waiting in the queue is computed. This information can help design the waiting spaces. Here, the max storage level is 1774 servings during the event, and the max queue in length is 1329 customers.

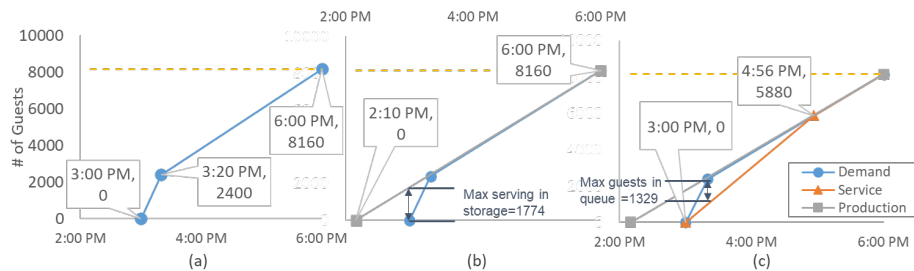


Fig. 4. Rough Capacity Planning

3.4 Detail Planning

The rough capacity plan shows that P is 37 servings/minutes; the maximum storage level is 1774 servings; the maximum customer waiting is 1329 customers. These figures are as input to the detailed planning stage to compute the number of equipment needed. Using information from **Table 1**, the number of grills and warmers can be calculated as **Fig. 5**. “Adjustment” columns are for fine-tuning the number of grills and heaters; “Batch in Food Line” shows the average amount of food already placed on the food lines.

Prod Rate servings/min

Item	Adjustment	Batch	Cook Time	Preference	# Grills	
1 Burger	44%	40	12	0.9	4.44	
2 Hotdog(S)	57%	40	8	0.7	2.96	
3 Hotdog(L)	80%	40	10	0.5	3.70	
4 Chicken	47%	40	10	0.85	3.70	
#Grills = (Prod Rate x Cook Time x Preference / Batch) x Adjustment					Total Grills	15.00

Max Inv servings

Item	Adjustment	Batch	Preference	Batch in Foodline	# Heater	
1 Burger	44%	40	90%	6	11.74	
2 Hotdog(S)	57%	40	70%	6	11.74	
3 Hotdog(L)	80%	40	50%	6	11.74	
4 Chicken	47%	30	85%	6	17.65	
#Heaters = (Max Inv x Preference / Batch) x Adjustment - Batch in Food Line					Heaters needed	53.00

Fig. 5. Illustration of Detail Planning Calculations

The planners can use a table such as **Fig. 6** from the analysis done in sections 3.2 and 3.3 to decide the system: the number of grills, the number of food lines, and the

number of warmer. Different kitchen capacity (grills) and service capacity (food lines), different cook start times, the numbers of warmers, and the sizes of waiting buffer are needed. The result shows that, given the demand profile (2016), the latest cook start time (Fig. 6(a)) is determined by the kitchen capacity planned. On the other hand, the waiting buffered required (Fig. 6(c)) at each food line depends on the number of food lines designed.

4 Conclusion

Event catering plays a vital role in creating memorable events. Due to some distinct characteristics such as long setup time, time-varying demand, and complex customer food preferences, it is hard to keep high customer satisfaction with low food wastage. However, planning event catering still highly relies on planners' experience nowadays, there is a lack of decision models developed for planning aid.

This paper uses a service engineering approach to develop a framework for planning event catering to guide planners to determine kitchen capacity, temporary storage level (warmers), and staffing level in buffet service. The framework consists of three phases: System Analysis and Design, Kitchen and Service Synchronization, and Detail Planning. The tool provides planners a systematic way to plan event catering and intuitive visualization for decision making. Another benefit of the framework is that the queueing analysis in the framework is distribution-free, so only a few parameters are needed to run the analysis. A case study – military day tailgate party held by Penn State University is studied. In the future, we will extend this model with other critical features in event catering, such as food wastage and cook lead time. Also, the model will be validated with different types of case studies.

number of grills	Start Time	number of food lines					number of grills	Max Warmer	number of food lines				
		10	11	12	13	14			10	11	12	13	14
12	12	90	90	90	90	90	12	112	118	118	118	118	
13	13	70	70	70	70	70	13	94	100	100	100	100	
14	14	50	50	50	50	50	14	73	77	77	77	77	
15	15	30	30	30	30	30	15	48	51	53	54	55	
16	16	20	20	20	20	20	16	34	36	38	39	41	
17	17	10	10	10	10	10	17	18	19	23	38	51	
18	18	0	0	0	0	0	18	0	6	29	48	65	
19	19	0	0	0	0	0	19	0	6	29	48	65	

number of grills	Max Queue	number of food lines				
		10	11	12	13	14
12	12	130	114	99	87	77
13	13	130	114	99	87	77
14	14	130	114	99	87	77
15	15	130	114	99	87	77
16	16	130	114	99	87	77
17	17	130	114	99	87	77
18	18	130	114	99	87	77
19	19	130	114	99	87	77

Fig. 6. Detail Planning

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