Coordinating service distribution through cooperative "YuuZuu" reservations

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***Abstract*—Services are perishable and are simultaneously produced and consumed. A reservation is a traditional and effective means for coordinating service demand and supply. In recent years, computerized reservation systems have been used widely by many service vendors such as airline companies and hotels to improve their profits. In this paper, we propose and describe a "YuuZuu" reservation that motivates cooperation among customers with different preferences for services. It increases utilization of vendor-provided services. The DREAM reservation system, which is an implementation of "YuuZuu" reservation, comprises three functions: (1) reservation allocation, (2) price optimization, and (3) demand prediction. Preliminary experiments show that the DREAM reservation system outperforms a standard reservation system when some customers are insistent upon detailed preferences and others are not, which, we believe, reflects real-world conditions.**

I. Introduction

A scientific definition of services remains a matter of controversy among many researchers in several fields such as economics, computer science, and operations research. However, it is beyond question that services have several fundamental features that are not shared with other types of products. One feature is *simultaneity* of supply and demand for services: services must be consumed at almost the same time that they are provided (e.g., dinners at restaurants should be eaten when they are served.). Another feature is *perishability*: services cannot be stored as inventories. For instance, it is impossible to purchase a consultation with a doctor in advance and use it when you become sick, although one can stockpile drugs and take them in case of a cold or upset stomach.

Therefore, for efficient distribution of services, it is critically important to develop a method to coordinate the demand and supply of services in terms of three criteria: (1) quality of services should satisfy customers' requirements, (2) services must be provided in the quantity that customers demand, and (3) services must be available at the time when customers demand them.

Making a reservation is a simple but effective solution that meets the criteria described above. However, in this paper, the authors show that current reservation systems impose severe limitations. For that reason, they fail to achieve efficient allocation of services to customers. We therefore propose some enhancements to the existing reservation systems and show that they are effective for increasing profits of service providers and satisfaction of service consumers.

A. Simplistic Scenario

Legacy reservation systems cannot fully accommodate customers' preferences: requirements and flexibility about the services they want to reserve. First, we explain a situation in which a reservation system fails to satisfy customers' demands using a very simple exemplary scenario.

TABLE I
SIMPLE EXAMPLE

Departure	Available Seats
8:10	4
8:20	2
8:30	3

Table I presents hypothetical data related to some flight schedules and seat reservations. Presume first that one customer comes with the intention of reserving a seat on a flight that departs either at 8:10 or at 8:20. Finding that seats on both flights are still available, the customer makes a reservation for the 8:10 flight without a specific reason. Further presume that a pair of customers come to make reservations for seats on either the 8:20 flight or the 8:30 flight. Seeing that both flights have available seating, they happen to reserve two seats on the 8:20 flight.

Subsequently, a group of four people come and want seats on the 8:10 flight. The current reservation system cannot satisfy their demand because, by that time, the 8:10 flight has only three seats available because of prior reservations.

TABLE II
RESULT OF THE LEGACY RESERVATION SYSTEM

Departure	Available Seats	Reserved Seats
8:10	3	1
8:20	0	2
8:30	3	0

Table II summarizes the reservation result obtained using a conventional reservation system. Six seats remain unsold and only three reservations are made for customers. These lost opportunities and empty seats represent a loss to an airline company for two reasons: low utilization of capacity (i.e. seats of airplanes) and loss of customers' satisfaction (i.e. the last customers might use a flight of another airline).

TABLE III
RESULT OBTAINED USING THE PROPOSED RESERVATION SYSTEM

Departure	Available Seats	Reserved Seats
8:10	0	4
8:20	1	1
8:30	1	2

What if the reservation system can elicit customers' intentions about their preferences of the flights and exploit those preferences to rearrange the reservations based upon requests of late-arriving customers? In the previous example, the reservations for the pair of customers can be shifted to the 8:30 flight. Because this move produces two available seats for the 8:20 flight, the reservation of the 8:10 flight can be changed to the 8:20 flight. Consequently, the group of four people can make reservations for the 8:10 flight. Table III shows the improved reservation results. Unsold seats are reduced to two from six of the legacy reservation system and reservations are increased to seven from three.

To develop a reservation system that re-arranges reservations using customers intentions, many problems must be solved: (1) how to re-arrange reservations efficiently for satisfying late-arriving customers' demands while maintaining consistency of early-made reservations; (2) how to develop an incentive mechanism to promote elicitation of customers' intentions, which are used for re-arrangements of reservations; and (3) how to determine prices of reservations that improve both the service provider's profit and service consumers' satisfaction. In this paper, we propose and describe the "YuZuu" reservation system, which solves those problems. We also show its implemented system, the Dynamic REservation Allocation and Management (DREAM) reservation system.

B. Related Research

In recent years, many proposals, arising from scientific and engineering investigations of services, have been made in areas of "Services Science", "Service Engineering" and "Services Sciences, Management and Engineering (SSME)" [1], [2], [3]. Of those proposals, some provide comprehensive but ambiguous viewpoints on services and others emphasize the solution of a specific problem related to services (such as design and validation of services). The authors' understanding is that we are in the age of creating a new discipline on the research of services so that discussion based on empirical results related to services might be of interest to many researchers and practitioners.

Our research on reservations as a distribution method of services is based on studies of operations research (OR) and manufacturing. Because a function of reservations is the dynamic allocation of services to customers, the objectives of a reservation system resemble those of scheduling [4] in manufacturing because the objective is the efficient temporal allocation of resources to jobs for maximizing manufacturers' profits. Unlike manufacturing, where rich information related to demand and capacity is available for solving a scheduling problem, service vendors have not been readily accessible to such information. However, because of the recent advancement and popularization of Internet technologies, those types of information have become obtainable also in the services industry. In this paper, we apply constraint-based search techniques used in scheduling [5] for solving a reservation problem.

Another process related to reservations is price setting. Because the objective of pricing is to maximize the profit of service providers, it is highly related to yield management (or revenue management) [6] in OR. Nevertheless, because development and deployment of revenue management systems requires long-term preparation and a huge investment, only large companies such as airlines or hotel chains can afford such systems. We offer a much simpler means of enhancing profits for service providers. Prices are discounted to give customers an incentive of revealing their preferences on the items they want to reserve. In addition, premium prices are offered to late-arriving customers who desperately seek already-reserved items. That pricing allays costs of the re-arrangement of reservations. Profits are expected to increase as a result of improved utilization of services, as explained in Section I-A.

Our proposal of applying manufacturing and OR technologies to services is not new. One author applied a scheduling methodology to make a dynamic plan of visitors' activities in an amusement park for eluding congestion and improving visitors' satisfaction [7]. In addition, in Japan, there have been several trials of techniques or concepts related to the Toyota Production System (TPS) [8] to service industries such as supermarkets and postal offices for improving their respective productivities. The "YuuZuu" reservation system explained in this paper is another example of improving service distribution by applying knowledge and techniques of manufacturing and operations research.

The remainder of the paper is presented as follows. In Section II, we explain the general idea of "YuuZuu" reservation. Then in Section III, we discuss functions of its implementation, the DREAM reservation system. Then, in Section IV we describe the results of preliminary experiments obtained from application of the DREAM reservation system to an imaginary hotel-chain reservation problem. Finally Section V concludes the paper.

II. "YUUZUU" RESERVATION

"Yuuzuu" is a Japanese word meaning elasticity or flexibility. We propose a reservation method that accommodates demands of customers and supplies of service vendors for increasing both customers' satisfaction and vendors' profit.

As shown in Figure 1, "YuuZuu" reservation presents three ways of making a reservation: (1) a *regular reservation*, which is identical to that made using the current standard reservation method; (2) a *flexible reservation* (with a discounted price); and (3) a *picky reservation* (with a premium price and strong preferences). Among those three types of reservation method, the flexible reservation and the picky reservation are unique to

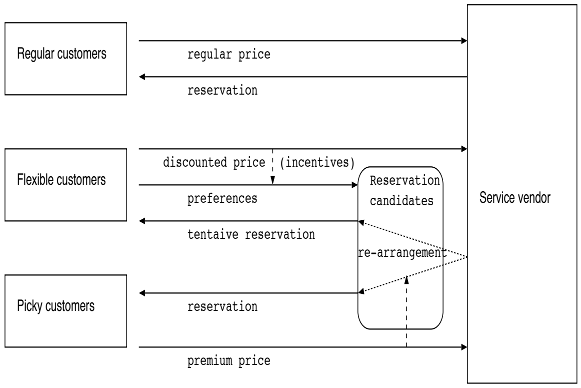

Fig. 1. ”YuuZuu” reservation

“YuuZuu” reservation; they are inextricably linked. We call a customer who makes a flexible reservation a flexible customer and call a customer who makes a picky reservation a picky customer.

For the flexible reservation, a customer expresses preferable candidates about a reservation and makes one candidate as a tentative reservation while entrusting the final fixation of the reservation to the reservation system. The customer agrees that the system might exchange the tentative reservation with another expressed candidate up to a certain time point. They do not care which candidate will become their final reservation until the time point. As described in Section I-A, customers’ preferences on the items to be reserved are precious information for service vendors to make arrangements using demands of late-arriving picky customers who come to the reservation system, whereas flexible customers wait for the system to fix final reservations for them. Therefore, to give flexible customers an incentive to express a wider range of reservation candidates and wait longer until a final reservation is fixed, the price for the reservation is discounted from the regular reservation price.

The picky reservation is made when no item is left available for satisfying a late-arriving customer’s demand unless some existing tentative reservations of flexible customers are re-arranged with other candidates. Such re-arrangements are costly for maintaining consistency of all reservation data, thus the picky reservation should be considered as a special treatment for those who desperately need certain reservations. Therefore a premium price is charged for making the picky reservation. A customer, such as a business traveler, who strongly insists upon a seat on a specific flight which was already fully (although some seats are tentatively) reserved might agree to pay an extra amount of money to reserve a seat on the flight.

For the flexible reservation and the picky reservation, pricing is tightly integrated with reservation. Prices are determined based upon values of items to be reserved for customers. A flexible customer might be indifferent about the departure time of the flights as long as the customer can arrive at a destination within a day of departure. For such a customer, each flight has no special value. However, a picky customer might need a flight that departs at a specific time because of related connections of subsequent flights to a final destination. For that customer, the flight is much more valuable than other flights, especially when no seat is available when the customer wants to make a reservation. Using the “YuuZuu” reservation system, prices are marked down or up automatically based on the mode of reservation (i.e., whether flexible or picky) reflecting customers’ needs and preferences. In traditional reservation systems, prices are determined using a revenue management system. In revenue management, several techniques such as class segmentation and dynamic pricing have been developed and used for increasing profits of vendors, but applications of those methods require careful preparation and investment so that only very large companies can afford them. “YuuZuu” reservation helps small-scale service providers increase profits and gain customers’ satisfaction by providing a simpler pricing method that is compatible with traditional revenue management methods.

III. DREAM System

The DREAM reservation system is an implementation of the “YuuZuu” reservation method. Actually, DREAM consists of three components depicted in Figure 2.

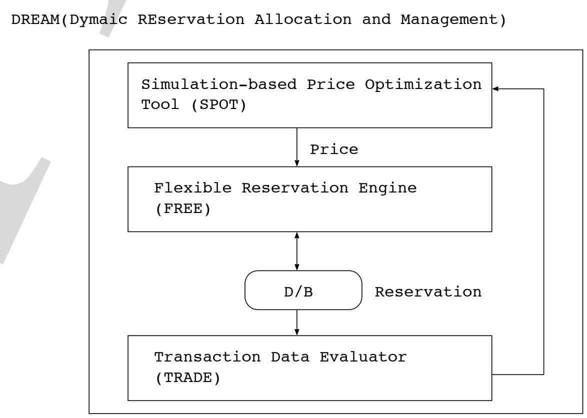

Fig. 2. Architecture of the DREAM reservation system

The Flexible REservation Engine (FREE) is the core of the reservation system, which allocates items according to various types of reservation requests. The Simulation-based Price Optimization Tool (SPOT) determines the price of items for each type of reservation (i.e., regular, flexible and picky) through repeated simulation and optimization. The TRansaction Data Evaluator (TRADE) analyzes the records of reservations and predicts future demand for items, which are then used as input data of the simulations executed by SPOT.

A. *Reservation Allocation*

The most fundamental difference between DREAM and other standard reservation systems is the constitution of its database. In standard reservation systems, the database has only two types of data related to reserved items and free items. As shown in Figure 3, the database of DREAM deals with two additional types of data: tentative reservations items and spare candidates.

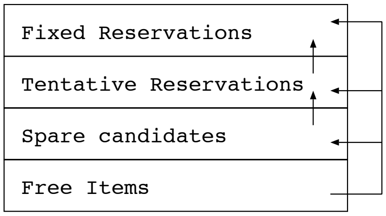

Fig. 3. DREAM database

In making a flexible reservation, a customer is required to specify more than two items as candidates of the reservation. One candidate, which the customer prefers most, is stored as a tentative reservation in the database. The others, which are substitute reservations, are stored as spare candidates. The flexible customer determines the time point at which a current tentative reservation is fixed as a final reservation for the customer. Based upon the number of candidate items and the time left to the fixation time point, a discount price for flexible reservations is calculated dynamically based on the parameter values determined by SPOT.

When a picky customer uses DREAM and seeks to make a reservation for a service that has already been tentatively reserved, FREE shifts a spare candidate, which has the next highest priority for the flexible customer, to a new tentative reservation for the flexible customer. Re-arrangements of tentative reservations for flexible customers might occur until the time point of reservation fixation specified by the flexible customers when spare candidates remain available for them. For making a picky reservation, a customer is required to pay a premium price to allay costs of making complicated re-arrangements of reservations. Even the very simple case explained in Section I-A required changes of two customers' reservations to accommodate a request of the late-arriving customer. The situation becomes more complicated when customers make a reservation for more than one item. In such a case, which is normally encountered in daily reservations situations, rearrangement of a single reservation might require exchanges of multiple items. Those items also must be exchanged further if the exchanged item is included in a reservation of multiple items. This propagation of re-arrangements might require much computation and impart widespread ripple effects on reservations.

For arrangement of reservations, DREAM adopts heuristic anytime search used in general search problems [9] and constraint satisfaction problems [10] to regulate the time required for the search and to control the influence of reservation re-arrangements on the remainder of its database. In the database, the DREAM reservation system has a set of reservations $R = \{R_1, ..., R_n\}$, which are divided into three types such as fixed reservations $F = \{F_1, ..., F_{n_f}\}$, tentative reservations $T = \{T_1, ..., T_{n_t}\}$, and spare candidates $S = \{S_1, ...S_{n_s}\}$. Each reservation R_j has a set of reserved items $I^j = \{I^j_1, ...I^j_{n_j}\}$. We assume that the DREAM reservation system has a picky

Require: A set of items to be reserved I^P
Ensure: SUCCESS or FAILURE

```
1: sort I^P in the order of difficulty to reserve
2: for all i ∈ 1, ..., n_P do
3:   if I_i^P ∈ F_j then // item is fix reserved
4:     return FAILURE
5:   else if I_i^P ∈ S_k then // item is spare reserved
6:     for all S_s such that ITEM ∈ S_s do
7:       T(S_s) ← a tentative reservation for S_s
8:       if T(S_s) has no other spare candidate then
9:         change T(S_s) to a fixed reservation
10:      end if
11:    end for
12:  else if I_i^P ∈ T_l then // item is tentative reserved
13:    SW ← 0 // SW is search width
14:    SD ← 0 // SD is search depth
15:    if rearrange_reservation(T_l) == FAILURE then
16:      return FAILURE
17:    end if
18:  end if
19: end for
20: return SUCCESS
```

Fig. 4. Function: picky_reservation

customer P who wants to reserve items $I^P = \{I^P_1, ..., I^P_{n_P}\}$.

Figure 8 shows the algorithm used to make a picky reservation. To improve the search efficiency, items requested by a customer are sorted in the order of difficulty for reservation (line 1 in the algorithm). The definition of difficulty is heuristic. In a current implementation, items reserved by a tentative reservation with fewer spare candidates are considered to be more difficult to reserve.

A reservation is processed as a picky reservation when a customer requests items that are already tentatively reserved (line 12 in Figure 8). In that case, DREAM sets two global variables, SD and SW, to control the extent of the search and calls a function `rearrange_reservation` for re-arranging the tentative reservation that already reserves the requested item.

The pseudo-code of the `rearrange_reservation` function is shown in Figure 5. This function is self-recursive; the parameters SW and SD are used to interrupt recursion of the function. In the function, spare candidates of the tentative reservation to be re-arranged are sorted heuristically in their order of difficulty of re-arrangement. In addition, each item in the spare candidate is also sorted similarly. Then items are checked for whether they can be re-arranged to a tentative reservation. If an item is included in a tentative reservation of another customer, the tentative reservation also must be re-arranged. In this way, ripple effects of the re-arrangements might propagate unexpectedly to the large extent of existing reservations. To reduce such risks, we control search processes using heuristics, such as variable ordering and anytime algorithms.

Require: Tentative reservation T_l to be re-arranged
Ensure: SUCCESS or FAILURE

$SD \leftarrow SD + 1$
if $SD >$ MAX_DEPTH **then**
  return FAILURE
end if
$S(T_l) \leftarrow$ spare candidates of T_l
sort $S(T_l)$ in the order of difficulty to re_arrange
for all $S_i \in S(T_l)$ **do**
  $SW \leftarrow SW + 1$
  if $SW >$ MAX_WIDTH **then**
    return FAILURE
  end if
  $I(S_i) \leftarrow$ items in S_i
  sort $I(S_i)$ in the order of difficulty to re_arrange
  STATUS $\leftarrow$ SUCCESS
  for all $I_j \in I(S_i)$ **do**
    if I_j is tentatively reserved in T_k **then**
      if rearrange_reservation(T_k) == FAILURE **then**
        STATUS $\leftarrow$ FAILURE
        break
      end if
    end if
  end for
  if STATUS == SUCCESS **then**
    return SUCCESS
  end if
end for
return FAILURE

Fig. 5. Function: rearrange_reservation

B. Price Optimization

In the current implementation of DREAM, three types of parameters determine the reservation price. We do not claim that the following is the best price setting method for DREAM, but in Section IV we show empirically that even this simple pricing method can be quite effective in increasing vendors' profits and customers' satisfaction in DREAM.

$$p_d = p_r(1.0 - \alpha f(n, l)) \quad (1)$$

One parameter is a discount ratio for a flexible reservation. In Eq. 1, p_d is a discounted price, p_r is a regular reservation price and $\alpha(\geq 0)$ is a discount ratio. Actually, $f(n, l)$ is a function to calculate the elasticity of reservations based on the number of reservation candidates (n) and the time left until reservation fixation (l).

$$p_p = p_s(1.0 + \beta) \quad (2)$$

Another parameter is a premium ratio for a picky reservation. In Eq. 2, p_p is a premium price, p_s is a referential standard price for an item to be reserved, and $\beta(\geq 0)$ is a premium ratio.

$$p_r = p_s(1.0 + \beta\gamma) \quad (3)$$

The last parameter is a parameter to control a regular reservation price based upon the data of present sales and the expectation of the future sales. In Eq. 3, $\gamma(\geq 0)$ is the parameter to control a regular reservation price.

TABLE IV
EXAMPLE OF γ VALUES

(%)	0 - 20	20 - 40	40 - 60	60 - 80	80 - 100
0 - 20	0.0	0.1	0.3	0.4	0.5
20 - 40	0.1	0.2	0.4	0.5	0.7
40 - 60	0.2	0.3	0.5	0.6	0.8
60 - 80	0.4	0.5	0.6	0.7	0.9
80 - 100	0.5	0.6	0.7	0.9	1.0

Table IV shows an exemplary setting of γ values. Each column shows the values of $gamma$ at a certain range of sales. Left columns represent situations when sales are small: the value of γ is set small to keep prices low. Right columns show good sales: values of γ are large. Each row shows values of γ at a certain time range. Upper rows represent situations in which there is little time left for making reservations: the value of γ is small. In lower rows, values of γ are large because there remains sufficient time for future customers to make reservations.

In DREAM, SPOT optimizes values of the two parameters (α and β) and the table of γ values using parallel genetic algorithm running on a cluster computer. For simulations, demand data are predicted based on the outputs of TRADE or created manually, as in the Learning Curve Simulator [11]. Moreover, DREAM users can override the optimized parameter values using values of their own choice.

C. Prototype System

Based on the DREAM architecture, we implemented a prototype web-based reservation system for an imaginary hotel chain.

Fig. 6. Flexible reservation

Figure 6 shows a web page at which a user selects three candidate hotels for the customer's flexible reservation. The customer also selects the time until fixation of the reservation from among three candidates. Based on the number of candidates and the time length until fixation, discounted prices are shown in the figure.

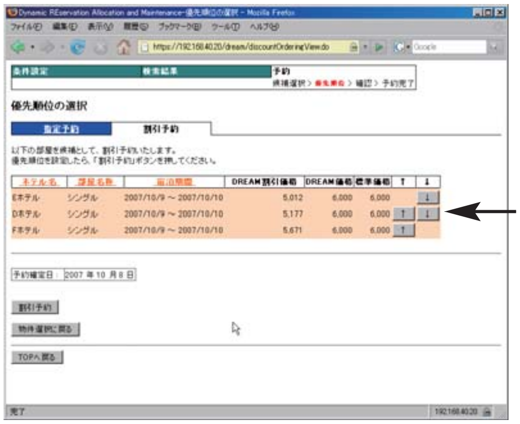

Fig. 7. Priority of candidates

For the flexible reservation, a customer can also change the order of preference of candidates. As shown in Figure 7, the order of preference of candidates can be changed interactively using the up and down arrow buttons.

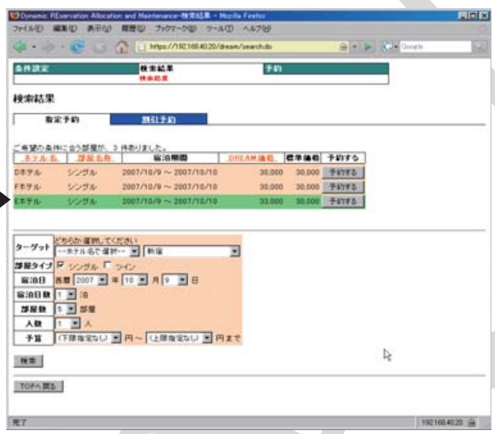

Fig. 8. Picky reservation

A customer can still make a picky reservation of the item when an item had been tentatively reserved with some spare candidates for the reservation. Figure 8 depicts an example in which the third candidate with the green background can be reserved by paying a premium price. If a customer absolutely requires this item, the customer might prefer to pay an extra amount of money for making a fixed reservation rather than risk losing it.

IV. Preliminary Experiments

As preliminary experiments, we compare the results of the "YuuZuu" reservation system and those of a standard reservation. The metrics for comparison are the average resource utilization, the average reservation price, and total profit. We show empirically that a "YuuZuu" reservation simultaneously improves vendors' profits and customers' satisfaction.

A. Hotel Chain Problem

We set up a problem of an imaginary hotel chain to evaluate performances of "YuuZuu" reservation. The following are descriptions of the assumptions made in the experiments.

1) The hotel chain has 10 hotels operating independently.
2) Each hotel has 100 rooms.
3) A referential price of all the rooms is 10,000 yen.
4) Demands of customers are various for the hotels, ranging from 60% of its capacity to 200%; the averaged demand of all hotels is 100%.
5) Because of excess demand for popular hotels, only 80% of customers can make reservations of their first-choice hotels.
6) The budget of regular customers is 10,000 yen.
7) Picky customers are willing to pay up to 12,000 yen when required.
8) Arrivals of picky or flexible customers are randomly distributed with an assumption that picky customers tend to come later.
9) Flexible customers accept any hotel and postpone the fixation of a reservation until the last minute; the flexibility value (i.e., value of $f(n, l)$ in Eq. 1) is always set as 1.0.
10) For simplicity, all customers who are not flexible behave as picky customers when their priority item is already tentatively reserved by a flexible customer.
11) The values of α and β in Eqs. 1 and 2 are set as 20%.
12) The values of γ in Eq. 3 are all 0.0 when they are not optimized. Optimization sets γ values between 0.0 and 1.0.

B. Results and Evaluations

In the following experiments, we show how the performances of the reservation systems change according to the ratio of flexible customers in the whole customers. Therefore, in every graph of this section, the X-axis shows the ratio of flexible customers, which is shown as flexibility in the graphs. In addition, the Y-axis shows the values of various metrics that reflect different aspects of the reservation system's performance.

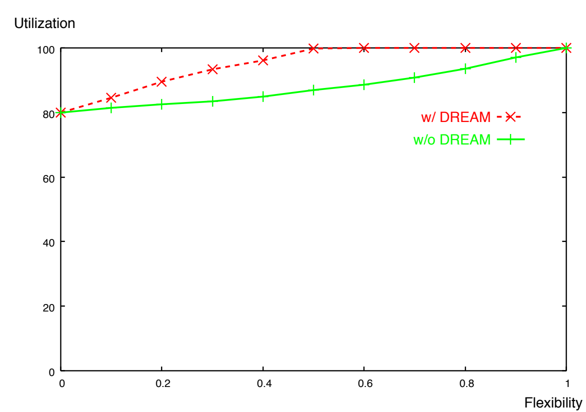

Fig. 9. Average utilization of resources

Figure 9 presents the result of average utilization of rooms in hotels. For a standard reservation system, flexible customers make a reservation at any hotel that has a vacant room, but picky customers give up reservations when their choice of hotel is already full. However, using DREAM, picky customers can be allocated to a room that is already tentatively reserved by flexible customers in cases where spare candidates are still available. Therefore, when no flexible customer exists (or when no picky customer exists), the reservation systems with and without DREAM produce identical results. However, when there are both flexible and picky customers, the DREAM reservation system always outperforms the standard reservation system without DREAM in terms of average utilization of resources (i.e. hotel rooms). For a service industry based upon the use of expensive capital assets, improvement of asset utilization is of the highest importance to increase revenue. This result shows that DREAM can be a key solution technology to the problem.

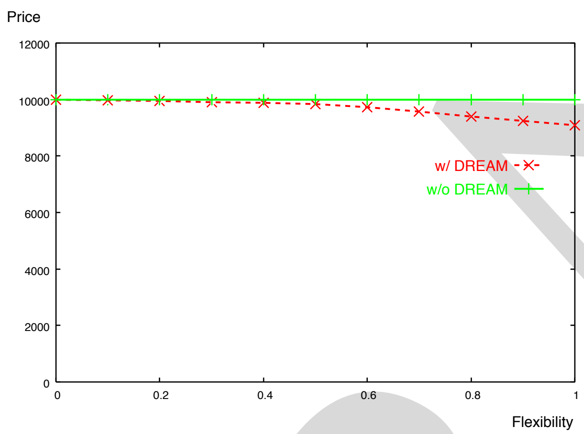

Fig. 10. Average price of reservations

Figure 10 depicts the average price of reservations made by customers. It is noteworthy that, because of the experiment's assumptions that set the same value (i.e. 20%) to the parameters α and β, the average price of DREAM is always smaller than that of the standard reservation system. For the DREAM reservation system, the average price of reservations decreases drastically when the ratio of flexible customers is greater than 50%, which might enhance customers' satisfaction but cause a loss of profit for the hotel chain. For that reason, we must investigate the influence of discounts by DREAM to the profit of service vendors.

Figure 11 shows that lines representing the profits made by two types of the reservation systems intersect at a certain point of flexibility. Although the DREAM reservation system can earn greater profits than the standard reservation system when the ratio of flexible customers is smaller than a certain value (in this experiment, it is about 80%), it fails to outperform the standard reservation system when more flexible customers exist. When there are too few picky customers, discounts made for flexible customers by DREAM cannot be compensated with premium prices paid by picky customers for re-arrangements of reservations. Consequently, when running the DREAM reservation system, the number of flexible reservations must be regulated by controlling price discounts to retain vendor profits.

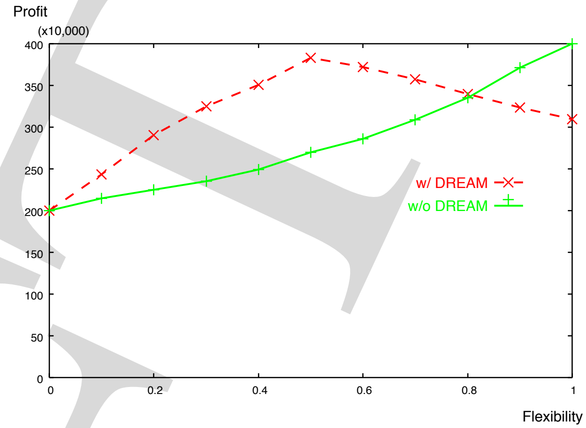

Fig. 11. Total profit

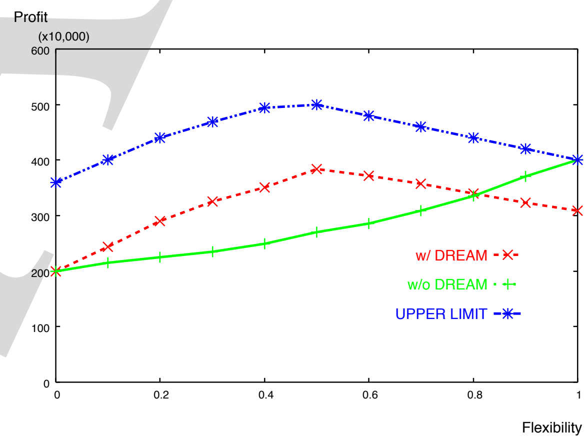

Fig. 12. Upper bound of profit

In Figure 12, the topmost line shows the upper bound of profits that can be achieved for the hotel chain. The values are calculated based upon some assumptions: (1) the reservation system knows a priori whether a customer is flexible or picky and charges a premium price to picky customers even when there is no need of reservation re-arrangements for them; and (2) flexible customers always agree to re-arrange their reservation without discounts to accommodate the requests of picky customers. Because these are unrealistic assumptions, the achievable profit of the hotel-chain is always lower than this upper bound.

In Figure 13, we show the results of optimizing γ values for both types of reservation systems. Because no randomness exists in the system when customers' flexibility is either 0% or 100%, the standard reservation system achieves the same profits as those of the upper bound. Comparing the optimized results of both reservation systems, the profits achieved using the DREAM reservation system are higher than those of a stan-

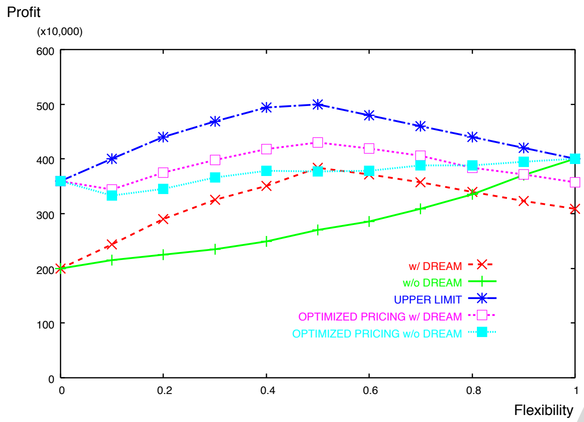

Fig. 13. Optimized profit

dard reservation system until customers' flexibility increased to 80%. Differences between the two reservation systems are smaller than those when γ values are not optimized, which shows that optimization has greater effects on the standard reservation system.

As shown in Figure 13, it is noteworthy is that the profits of the optimized standard reservation system are almost identical to those of the non-optimized DREAM reservation system in the range of customers' flexibility between 40% and 60%. When there is an appropriate number of flexible customers, the DREAM reservation system can earn comparable profits to those of the reservation system with optimized pricing. Because price optimization is usually executed using a sophisticated revenue management system and is therefore very costly, the DREAM reservation system is a reasonable profit-increasing alternative to the revenue management system for small-scale service vendors.

V. Conclusion

Service vendors must coordinate demands and supplies of their services to improve the efficiency of service distribution. Reservations have been widely used as an effective means to solve the problem. In this paper, we improve the traditional reservation method and propose "YuuZuu" reservation, which manages service allocation to meet customers' preferences more precisely and promotes cooperation among customers to improve their satisfaction and the service vendors' profits. An empirical comparison with the standard reservation system shows that the DREAM reservation system (which is an implementation of "YuuZuu" reservation) is effective for improving both customers' satisfaction (in terms of the number of completed reservations and prices) and the vendor's profit without expensive price optimization using the revenue management system.

"YuuZuu" reservation seems to be related with other economic trading methods such as an *auction* and an *option*. In auctions, bidders cannot tell whether they can acquire the item or not until the auctions end. But in "YuuZuu" reservation, customers are guaranteed to acquire some reservation no matter whether they are flexible or picky customers. Therefore "YuuZuu" reservation is more reliable than auctions for customers who need some items for sure. And (call) options gives a holder the right to buy an asset by a certain date for a certain price. Therefore, an option price payed by the holder is not a price of the asset but a price of the right to buy the asset, and the holder can choose not to exercise the right and lose the option price. Nevertheless, prices of "YuuZuu" reservation are for the items to be reserved and customers make their commitment to acquire the items when they make reservations. The difference between the option and "YuuZuu" reservation stems out of properties of the items to be reserved by "YuuZuu" reservation, i.e. they are not suited for the purpose of investment since they are perishable and lose their value after a certain time point.

The DREAM reservation system can be a powerful tool to enhance the productivity of service vendors. We are now developing a test system of an Internet portal site for golf-course reservation. We hope that we can report successful results of that test in the near future.

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