Analysis and design of service failure prevention system in online culinary business

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Abstract. Online culinary businesses are in charge of preventive service failure to avoid greater loss and keeping service performance. The losses occurred due to protracted customer disappointment with service failures which lead to worse churning customers. We propose a prevention system to identify and allocate the failure position. It also sets the action rules to failure. This requires to analyze the current failure structure and cause. This work used decision tree classification (ID3) to design the rule. The failure structure was denied by the component of delivery time and food quality. The parameters to allocate the failure were delivery time, traffic jam, rush hour ordering, weekend/weekday order, rain/not rain day, giving GPS/not, suitable order, food complement, and packaging quality. It had four failure types: none, low, medium, and high. The model had 73% of accuracy to classify failure. The action for low failure was in charge by the delivery man in the form to speed the delivery time not exceed 85 minutes and by kitchen staff in the form to check the order before it sent. The medium failure was in charge by the delivery man in the form to speed the delivery time not exceed 55 minutes in not rush hour order.

Keywords: decision tree classification, online culinary business, prevention system, service failure

1. Introduction
Service failure arises due to the inability of restaurants to meet the service expected by customers and the restaurant service standard. The risk because of the service failure is the emergence of customer disappointment [1]. Service is a service provided by a restaurant. In this paper, the service is the delivery time and food quality at the online culinary business. It is important to know what factors affect delivery time and food quality that cause failure or customer disappointment.

Imagine when the customer order food online because they are busy. The customer is very hungry and the food comes long because it is stuck on the road. When it has arrived, the food quality is not in expectation. It has no straw in the drink. The customer is very disappointed and thinks the restaurant is not able to serve well. Then the customer will not re-purchase and spread the bad image of the restaurant to their friends.

The prevention system for service failures is important for firm performance [1]. It relates to preventing the risk of churning customers. It also maintains the image of the restaurant as a service provider and keeping service performance. Preventive service failures aim to minimize losses or risk incurred due to customer disappointment with service. The result of losses is the unwillingness of
customers to repurchase. This was indicated by the poor rating of the restaurant. If the customer is satisfied with the service, it increases the willingness to return (WTR) [2].

The online culinary business (OCB) is a restaurant that sells food online. The customers order food online. The restaurant has its delivery driver. The restaurant has delivery and food quality as a service [3]. The OCB connects customers and restaurants via the internet. In the OCB, generally, the customers want information, friendly website design, security privacy, ease of payment, maintained food quality, fast delivery times and the readiness of employees to serve customers [4]. People use OCB services because they order comfortably and save time [5].

In this work, the OCB system is the restaurants that have their delivery system, especially in the form of using social media to order food. The OCB customers are in the age range of 13-25. The research conducted by [9] stated that fast food (one kind in the online culinary business) customers consumption in China is in the customer age between 13-17. Research by [10] claimed that young people have a high tendency towards fast food consumption. Those customers active plays social media. If they are disappointed with the restaurant service, they spread negative comments through social media and influence other customers to buy at restaurants.

The consistency of food quality issues for customer loyalty [6]. For example, when the restaurant has a lot of orders, it has potential the food complement left behind and lead to customer disappointment. These customer disappointments are prevented by becoming increasingly dangerous. If the number of disappointed customers minimized, then the restaurant has the probability to keep service performance. This is a way to prevent customers from being enemies for restaurants [7].

To know what is exactly the type of preventive action that proper to this work, first, it has to analyze the current failure structure and cause to know the potential factor that causes failure. Next, it allocates the cause of make rules. It used the decision tree (ID3) classification method. This method is suitable to build the fastest and short tree [11]. This method generates rules for classifying failure. Last, it is important to take action for each class of failure.

Therefore, the service failure prevention system is very important, so this is our main focus. Our goals in this paper are (1) to analyze the current failure structure and cause, (2) to allocate the failure position using rules with a decision tree, and (3) to take action on each type of failure. The scope of this paper is a service in the form of delivery time and food quality.

2. Literature review
The research by [12] said that the things that affect customer satisfaction in the OCB are food quality, delivery service, website quality, special offers, perceived risk, and convenience. This was also in line with what was conveyed by [13] that food quality and service quality was the thing that determines customer satisfaction with the OCB at fast-food restaurants in Vietnam. Food quality was related to the appearance and packaging of food and delivery services related to the time the order was received by the customer. The research conducted by [3] about the improvement of online food delivery service based on customer negative comments stated that the most common problems faced by food delivery online were delivery time (40%) and packing quality (12%). Next, he projected a solution to solve the problem. This was also an important issue in this paper.

The [7] said that after service failures or customer dissatisfaction occurred and companies also made minimal efforts to correct the problem, customers tend to become enemies of the company. Even though the customer had previously been very loyal. Customers distributed their disappointment by spreading negative word-of-mouth. This caused relationship quality between customers and companies to decline due to the reduction of trust, commitment and cooperation satisfaction.

To prevent this problem, companies do prevention service failure. The research conducted by [14] showed that restaurants could perform service recovery to prevent loss using verbal. This was a cheap and acceptable thing for customers. The customer accepted if the restaurant admitted its mistake via communication. Furthermore, [1] revealed that service interaction with the customer is dominant over monetary compensation.
In this work, we use the rating parameter from customer to evaluate service and indicate the service level. This paper focuses on delivery time and food quality because it is the most important thing in the OCB. This paper also uses nine categories: total delivery time, traffic jam, rush hour ordering, weekend/weekday ordering, rain/not ordering, giving GPS/not, suitable order, food complement, and packaging quality to determine failure class. This work fills the gap in the form of more parameters to determine the service failure classes in online culinary businesses using the restaurant's own delivery system.

3. Methodology

3.1. Research framework

This research was divided into two stages, analysis and design. The analysis phase was done by identifying the current failure structure and cause. This step was also the identification of the system requirements that want to build. The second stage was to design the rule-based for determining failure class using the decision tree. This step also made action for the prevention of service failure. Each stage had a critical success factor (CSF) to ensure the stages met the goals. The CSF was shown in table 1. Figure 1 illustrated the research framework.

**Table 1.** Critical success factors.

| Objective | Critical Success Factor |
|-----------|------------------------|
| 1         | The current failure structure and cause |
|           | System entity         |
|           | BPMN (business process modeling notation) diagram |
| 2         | Decision tree classification |
|           | Rules from decision tree |
|           | Classification accuracy |
| 3         | Action for each class of failure |
3.2. System development life cycle (SDLC)
This study used SDLC as a big idea. The stages of SDLC were planning, analysis, design, implementation, and maintenance [15]. The SDLC was a continuous process to improve system performance. The analysis and design phase was the most important stage in SDLC. In this study, the analysis phase was completed from objective 1 and the design phase was completed from objectives 2 and 3.

3.3. Identification of the current failure structure and cause
It was necessary to have an interview with the restaurant owner to find out the current failure structure and cause. It needed information on how restaurants did delivery time and check quality tags. This information was useful to breakdown the parameters used to allocate service failure. In this research, we took a local restaurant located in Bogor, Indonesia as a case study.

3.4. Information on system requirement
System requirements were used to map what was needed and desired by the system to be built. This stage explained in detail the components involved in the system. These components included inputs, processes, outputs, stakeholders, roles, missions, objectives, resources, opportunities, controls, and threats. All of them were summarized in the system entity diagram. Also, the system requirements were also illustrated through BPMN (business process modeling language) diagram. The BPMN diagram explained the information flow system for accomplishing a particular task needed by stakeholders for an organization to function [15].

3.5. Decision tree classification and rule
It used the decision tree (ID3) method to determine the failure class. This method was one of the supervised learning methods. The aim was to determine the label of data with the rule [16]. This method used input on how many data sets used as training data, attribute list, and attribute selection method. The parameters used in this method came from the failure structure and cause. The attribute selection method that used as information gain. It needs Entropy to calculated information gain. Entropy described the information needed to classify tuples in data (equation (1)). It refers to the impurity of data. The gain explained how many branches will be generated on the node. It also is a splitting attribute in ID3. The biggest gain will be the node of the tree (equation (2)). Figure 2 illustrated the decision tree basic algorithm. Next, it generated the rule for determining each class of failure. Generally, the process in this step was divided into input, process, and output. The input was the parameters form the previous step. The process was to design a decision tree. The output was rules for each class of failure.

\[ \text{Entropy} (D) = - \sum_{i=1}^{m} p_i \log_2 (p_i) \]  

(1)

Where \( p_i \) is the nonzero probability that an arbitrary tuple in \( D \) belongs to class \( C_i \).

\[ \text{Gain} (A) = \text{Entropy} (D) - \sum_{j=1}^{v} \frac{|D_j|}{|D|} \times \text{Entropy} (D_j) \]  

(2)

\( A \): set of cases  
\( D \): data partition  
\( D_j \): number of cases on j partition  
Attribute \( A \) with the highest information gain become a splitting attribute in node N.
3.6. Action for service failure

The results of class grouping from the decision tree then mapped the actions taken towards the class. It was intended that in the future the negative impact caused by customer disappointment not harm the restaurant too much. The results of this action were then handed over to stakeholders who in charge implement it, such as delivery man, kitchen staff, and management staff. This action aimed to keep service performance.

4. Results and discussions

4.1. The current failure structure and cause result

The result of the interview with the restaurant owner showed the restaurant did not have the system to prevent customer disappointment. The customers ordered from the restaurant LINE official. It had a standard in delivery time and food quality. The current service restaurant system was important to know the constraints of the restaurant. By the experience, the restaurant owner determined the service failure cause. The mechanisms of the service and the potential service failure is described below:

1. Delivery time
   - Delivery time was the total time from the customer's order until getting the order
   - Restaurants did delivery by order
   - The delivery fee was free
   - Maximum delivery orders were carried out within 5 km of the restaurant
   - Restaurants set a maximum delivery time of 50 minutes
   - The delivery man did the delivery order
   - Delivery man sent to several customers when the distance was close
   - Service failure sources:
     - The customer did not give the GPS (global positioning system) that caused delivery man took a long time to find the customer’s address
     - Traffic jam lead to a longer delivery time
     - The restaurant had many orders in the rush hour (11.30 AM – 1.00 PM) and (5.30 PM – 7.00 PM) so it took longer time to deliver the order
     - The rain caused delivery man took slow in the road
- In the weekend the restaurant had much order than weekday

2. Food quality
   - Food quality was good when it met the standards set by restaurants
   - The kitchen staff controlled the food quality
   - It controlled order fulfillment, packaging, and completeness of packaging
   - Service failure sources:
     - Mismatched orders
     - Incomplete fulfillment for order, including no spoons and straws
     - Broken packaging during delivery

4.2. System requirement discussion
In this step, we built the prevention system for service failure for the restaurant. This system allocated and took an action of service failure. It needed a system that made continuous improvements as well as actions when the potential service failure occurred. To build the system, it was useful to have a system entity diagram as illustrated in figure 3. This diagram showed the component that the system needs. Also, it was useful to have a use case and BPMN diagram to know stakeholders and their activity in the system. The BPMN diagram was shown in figure 4.

![System entity diagram](image)

**Figure 3.** System entity of service failure prevention system.

The system involved 5 stakeholders. The customer and mobile apps were as an external community and delivery man, kitchen staff, and management staff as an internal community (inside the restaurant). The solution in this paper focussed on management staff activity. He was responsible to identify and allocate and take action for service failure. The actions for service failure were given to the person in charge of the failure. Those were delivery man, kitchen staff, and management staff. The input was the service evaluation from customers and delivery men through mobile apps. These apps reported customer evaluation and sent it to the management staff. Next, the management staff did the identification, allocation and taking activities for the service failure. The output from this system was the action that was given to stakeholders that were responsible for the action.
4.3. Decision tree result

The goal of this step was the rule generation for preventive service failure. First, this step needed the data from the current failure structure and cause. It had nine categories: total delivery time, traffic jam, rush hour ordering, weekend/weekday ordering, rain/not ordering, suitable order, food complement, and packaging quality. It had one target class named failure. These data were gotten from the restaurant owner. This data was described in table 2.

| Metric Features       | Person in Charge | Unit       | Value                                      |
|-----------------------|------------------|------------|--------------------------------------------|
| Total delivery time   | Delivery man     | Minutes    |                                            |
| Traffic jam           | Delivery man     | Bin        | 0 (traffic jam), 1 (no traffic jam)        |
| Rush hour ordering    | Delivery man     | Bin        | 0 (rush hour), 1 (no rush hour)            |
| Weekend/weekday       | Delivery man     | Bin        | 0 (weekday), 1 (weekend)                   |
| Rain/not              | Delivery man     | Bin        | 0 (rain), 1 (not rain)                     |
| Give GPS/not          | Delivery man     | Bin        | 0 (not give GPS), 1 (give GPS)             |
| Matched order         | Customer         | Bin        | 0 (not suitable), 1 (suitable)             |
| Packaging quality     | Customer         | Bin        | 0 (bad), 1 (good)                          |
| Food complement       | Customer         | Bin        | 0 (not complete), 1 (complete)             |
| Failure               | Customer         | -          | none, low, medium, high                    |

The total delivery time was divided into three categories: long, medium, and fast. The long-time was the delivery time for more than 50 minutes. The medium time was the delivery time between 36-50 minutes. The low time was a delivery time under 35 minutes. Traffic jams, rush hour ordering, weekend/weekday ordering, rain/not rain day, suitable order, packaging quality, and food complement had a binary parameter. The failures were divided into four categories, none, low, medium, and high. The customer gave five stars for none failure, 4 stars for low, 3-star for medium, and two or one stars for high failure.

The data used for the decision tree is complete data. It meant both customer and delivery man filled the data. The management staff periodically updated the rule and action. The data was as presented in table 3.
### Table 3. Raw data for decision tree.

| Rec ID | Cus_ID | Tot. Del_time | Traffic Jam | Rush Hour | Weekday / Weeknd | Rain/ Not | GPS/ Not | Matched _order | Packaging Qty | Food Complement | Failure |
|--------|--------|---------------|-------------|-----------|------------------|-----------|---------|---------------|--------------|----------------|---------|
| 1      | 193    | 73            | 1           | 1         | 0                | 1         | 0       | 0             | 1            | 1              | none    |
| 2      | 98     | 49            | 1           | 0         | 0                | 0         | 1       | 0             | 1            | 0              | high    |
| 3      | 160    | 33            | 0           | 0         | 1                | 0         | 1       | 1             | 1            | 1              | high    |
| 4      | 36     | 88            | 0           | 1         | 0                | 0         | 1       | 0             | 0            | 0              | high    |
| 5      | 170    | 34            | 0           | 1         | 1                | 1         | 0       | 1             | 1            | 1              | none    |
| 6      | 126    | 57            | 1           | 0         | 1                | 1         | 0       | 1             | 0            | 0              | high    |
| 7      | 39     | 39            | 0           | 0         | 1                | 1         | 1       | 0             | 0            | 0              | high    |
| 8      | 132    | 75            | 0           | 0         | 1                | 1         | 1       | 0             | 0            | 1              | high    |
| 113    | 10     | 34            | 1           | 0         | 1                | 1         | 0       | 0             | 0            | 1              | none    |
| 114    | 95     | 85            | 0           | 1         | 0                | 1         | 0       | 1             | 1            | 1              | low     |

We worked on the decision tree classification with the Jupyter Notebook python programming language. We divide the data into 70% training data and 30% testing data. It used 3 max_depth of the tree. The results of the decision tree were as described in figure 5 and 6. From the model, the accuracy was 73%.

![Decision Tree Diagram](image-url)

**Figure 5.** Decision tree rule generation.
Based on figure 5, the rules obtained as shown in table 4.

**Table 4.** Effective rules generated for determination of service failure.

| No | Total Del_time | Rush Hour | Rain/Not | Suit_food | Packaging Quality | Failure |
|----|----------------|-----------|----------|-----------|-------------------|---------|
| 1  | X >= 85.5      | -         | -        | -         | No                | None    |
| 2  | X <= 79.5      | Yes       | Rain     | -         | -                 | None    |
| 3  | X <= 55        | No        | -        | -         | -                 | None    |
| 4  | X >= 85.5      | -         | -        | Yes       | -                 | Low     |
| 5  | 79.5 <= X <= 85.5 | -    | -        | No        | -                 | Low     |
| 6  | 79.5 <= X <= 85.5 | -    | Yes      | -         | -                 | Low     |
| 7  | X >= 55        | No        | -        | -         | Medium            |         |
| 8  | X <= 79.5      | Yes       | Not      | -         | -                 | High    |

**4.4. Action for service failure prevention system**

The previous stage helped us to classify failure with certain service characteristics. At this stage, we took action on the results of the classification. This meant to prevent service failure in the future. The restaurant had taken precautions so that the impact can be minimized. From the rules obtained in the previous stage, we made an action to prevent this from happening. The management staff balanced the action with the constraints of the restaurant. Here table 5 described some actions that can be done.
### Table 5. Action for service failures.

| Failure Type | Action                                                      | Person in Charged |
|--------------|-------------------------------------------------------------|-------------------|
| Low          | Speed the delivery max 85 minutes                           | Delivery man      |
|              | Check the food order before giving to the delivery man      | Kitchen staff     |
| Medium       | Speed the delivery max 55 minutes in not rush hour          | Delivery man      |

As you notice, not all the parameters and rules took to action. From 9 parameters before, only 5 parameters decided the rules: total delivery time, rush hour/not order, rain/not rain day, suitable food, and food complement. From the previous step, there were 5 rules to low, medium, and high failure. But, only 4 rules matched logically. Rule number 8 in table 3 was not logic. The management staff checked it first. The previous step helped us to classify a lot of evaluation data from the customer. But the important part came from the action that builds by management staff. This work used the random data. So it had high potential did not describe the real-world data. But the method worked well.

From this result, the management staff took action for low and medium failure. For low failure, the actions were in charge of the delivery man and kitchen staff. The low failure occurred when the delivery time exceeds 85 minutes and the order not suitable. So, the delivery man sped the delivery and the kitchen staff checked the order. For medium failure, the actions were in charge of the delivery man. The medium failure occurred when the delivery time exceeds 55 minutes in not rush hour order. So, the delivery man sped the delivery time.

#### 4.5. Testing scenario

Figure 7 and figure 8 were respectively shown the testing scenario for low and medium failure class action. It applied the use of case-based testing scenario. The use case diagram was a diagram that explained the functions and behavior of each stakeholder involved in the system [17]. After management staff allocated and made recommendation action for each type of failure, next it implemented by the person in charge. From table 5, the low failure occurred because of the delivery time exceed 85 minutes and mismatched order. So, the action to avoid this failure was taken by the delivery man and kitchen staff as illustrated in figure 7.

![Figure 7. The scenario for low failure class.](image)

From table 5, it also knew the medium failure occurred because of the delivery time exceed 55 minutes. So, the action to avoid this failure was taken by the delivery man. This scenario was illustrated in figure 8.
5. Conclusion and recommendation

Service failure prevention system is a system that keeping the service performance of the restaurant. It prevented customer disappointment. It was a challenge faced by restaurants in the online culinary business. The system started by analyzing the current failure structure and cause. It showed as the important service ware delivery time and food quality. The delivery time contained the total delivery time, traffic jam/not, rush hour/not order, weekday/weekend order, rain/not rain day, and giving GPS/not while ordering. Food quality contained suitable order, packaging quality, and food complement. Next, these parameters were used to develop a decision tree classification for designing rules to determine service failure. The result was rules for 4 failure classes, none, low, medium and high class. This model had 73% accuracy. The last stage was to make an action for each failure classes that carried out by the person in charge. The management staff compiled this action. From the 9 parameters before, only 5 parameters set the rule: total delivery time, rush hour/not order, rain/not rain day, suitable food, and food complement. There were 4 rules logically generated for low, medium, and high failure. The low failure was in charge of delivery man and kitchen staff while the medium failure was in charge by the delivery man. The actions for low failure was sped delivery time not exceed 85 minutes and checked the order before it sent. The action for medium failure was sped delivery time not exceed 55 minutes in not rush hour time.

However, this work only used two service parameters. It recommended adding more parameters, such as staff behavior, the staff responsiveness, and so on. And also it recommended testing the scenario with Markovian decision problem to get a better result.

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