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Pedestrians Flow Simulation for Theme Park Problems

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Abstract : In theme parks, it is important to make congestion such as waiting time reduce at each attraction. There are many trials to reduce waiting time by presenting congestion information to users, but it is also necessary to sufficiently verify those effects in advance. In this paper, we have developed an agent-oriented pedestrians flow simulator where a park visitor is modeled as a agent. Our simulator provides a simplified visualization function to confirm congestion conditions within the park. We also demonstrated elementary experiments for the really existent park.

Key words : Theme Park Problem, multi-agent system

INTRODUCTION

The theme park problem is one of examples for carrying out mass user support studies conforming to realistic problems [3]. The group user is not limited to only the support of the life and personal convenience, in anticipation of society, that of individuals gathered population and support that target, studies on group mass user support to a variety of social issues it is also a studies for solving. Underlying the group user assistance, society as a whole and individuals of convenience are those of how to pursue, it has been made widely studied from the point of view of theory and complexity by game theory and multi-agent system. In addition, as one of the important research fields in the group mass user support, there is the control of the pedestrians flow at the crowded situation in a number of people. A car navigation system is while realizing by congestion information system called VICS, a fictional conventional studies of theme parks and events venue, transportation, such as to model the situation, it was verified the relaxation of the whole of congestion using multi-agent simulation experiments were conducted [2]. The results, the congestion information that each agent is provided by the system, the person dislikes waiting becomes possible to shorten the waiting time by the avoidance of congestion based on the information, there is certainly effective was. But, it would created a congestion elsewhere is that the congestion avoidance destination a lot of agent has been presented congestion information based on as an attempt to avoid congestion resulting in the avoidance of congestion, result, sometimes the whole of the congestion degree becomes not less decreased [1], [2], [3].

In this study, as the target of the theme park problem, we developed a pedestrian flow simulator that models the customer as an agent. This simulator is a multi-agent system, also, the reality of the theme park is Tokyo Disneyland as a target the modeling of the theme park, we have done a visualization of the pedestrians flow. And, it performs a presentation of the congestion by using this simulator, under the settings that can confirm agents is park visitor all presented the congestion, changes in the updated congestion the time interval for presenting by carrying out and verifies the change in the average transfer time and the average waiting time for the entire agent, also, performs the verification of the change in the number of times the agent has received the service is the average of the total number of ride the attraction.

OVERVIEW OF RESEARCH FIELD

Theme park problem

The theme park problem visitors as agent, visited thousands from a few hundred agents within theme park consist of plurality of facilities and road, the visit schedule by adjusting, the improvement of the satisfaction of the whole of agent this is a problem that purpose [1]. Without having to injure the individuals and entire benefit from how decentralized information, such as how to schedule coordination between many individuals is a kind of dynamic scheduling problems, in various social life it can be regarded as a turned into simplify the problems to large-scale dynamic scheduling appearing. Often it is taken up as an example of a group mass user support studies, as the reason

・Behavior and preferences of the individual is likely to be modeled, also likely to discuss the utility of group mass user support

・People's behavior has a outside the boundary, the problem is closed

・Dealing schedule from a few hundred thousands of the order, as a starting point it is right amount of scale

・Induction adjustment support effect of is likely to verification and discussion for the group user

Etc. may be mentioned.

Conventional studies on the theme park problem, the behavior by adjusting of the visitors agents, that improves the overall efficiency of the theme park adjustment algorithm of developing emphasis is placed on the side. Moreover, the

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model of the imaginary theme park to using the concept of a complex network, applying the adjustment algorithm has been done comparison and verification of the experimental results obtained in the test conducted by the multi-agent [3].

Mass user support

The group mass user support, it in anticipation of the society at large, individuals gathered population by the support, studies on group mass user support is also a studies in order to solve various social problems. Limited social resources (facility use, road traffic, mobile, energy) when it is supplied to the user group in real time, without impairing the convenience and comfort of each agent, society as a whole of efficiency to improve it is an object of the group mass user support system to achieve.

Underlying the group mass user support are those of whether to how pursuing the convenience of the society as a whole and individuals, over widely has been carried out studies from the point of view of theory and complexity by game theory and multi-agent system. Moreover, in order to apply to the real world problems, it must be researched to reach by a more realistic group user model. Theme Park problem is what is proposed as one example for solving such a problem [6].

Pedestrians flow simulator

Pedestrians flow simulation technology to simulate the flow of pedestrians by the multi-agent system is a field that has been carried out actively research. Application has also been actively carried out, for example, at the time of evacuation and evacuation to tunnel fire verification of evacuation from the ship, from the high-rise building, verification of the congestion situation in the station yard, verification of the method of inducing near stadium where the Olympic Games were held it is used at equal[7].

Method for analyzing a pedestrians flow example vary depending on the purpose, pedestrians flow simulator using the techniques of multi-agent system is a method of expressing an individual the pedestrians flow to be analyzed in one of the agent in the simulation. Pedestrians flow simulator using a multi-agent system technology, for each agent can be controlled whether to take any such action, there is flexibility for the simulated want situations and scenarios.

In the theme park is a plurality of customers and the agent visited the theme park in each schedule, it may produce a long queue by attraction, and thus change the schedule of another agent. Thereby considered possible change in the flow of pedestrians.

Multi-agent system

Agent

The term agent is used in many ways in many areas. Constituent units be analyzed agent also vary, aggregates and modules of nerve cells be smaller, the larger and one person and person collective such as a unit. The agent on which unit research field by either capture is classified, has been studied with a specific analytical method in the field. Agent of in this research, as a unit the one of the guests visiting the theme park.

Multi-agent system

A multi-agent system is a system composed of a number of autonomous agents, have been used in such a distributed manner (coordination) problem solving and complex phenomenon[4][5] emergence. Their own standard of value according to that can freely choose their own act autonomous agents coexist number in an environment where, set a large number of multiple and it is certain or more agents, constitute an artificial society, each characteristic different and mutual effects agent is a system for simulating. Moreover, as a feature, the human society such a seemingly unpredictable events models with different personalities, it is a actually occur that can to try to recreate the situation that aims system. A multi-agent system was introduced is a simulator as the real thrill of multi-agent simulator, is system emergent overall behavior as an effect of the interaction between agents, by its behavior is fed back to the agent, even to system designers unexpected that may result in result it includes those. Allocation and division of problems dynamically in response to changes in the agent's situation and its place is your environment and performs.

Evacuation simulation as an example of research using multi-agent system and the like. It is, as an agent for inducing members and evacuees, and performs the one of simulation performed is evacuated to how to safely and smoothly by the simulated under the conditions such as building fire. Further, in the conventional research in theme park problem is modeled by the multi-agent system the guests, for congestion mitigation have been made verification of the effect of the induced adjustment support [1],[2],[3].

DESIGN MODEL

Basic policy

In this study, to target Tokyo Disneyland is a real theme park. It is carried out modeling the guests who visit as an agent, a simulator that was visualized pedestrians flow in 2D to develop. Fig.1 shows the process of the simulator, and Fig. 2 shows the operation of the basic processing of the agent.

As this simulator is the whole process, only the number of agents in until the elapsed time is the end time set performs the processing of the agent, only the number of attractions to the calculation of the expected wait time for each attraction, in the form of drawing it makes the output.

In the process of the agent you make a selection of attractions that becomes the destination by updating the congestion situation of attraction is performed. For attraction to select a destination, it is determined based on the preference of the attraction with each of the agent.

The agent confirmed presented expected waiting time, the information on the basis of you can either that is another destination attraction choose avoid matrix, or to be or line up to the matrix of the attraction behavior to determine.

If you line up to the matrix, wait for the order are added to the queue, it is the added to the service in the list of attractions once the order of the agent came to within attraction occupancy, then, to receive services. If not arranged to a matrix, and continues to move toward the attraction is the destination that is set.

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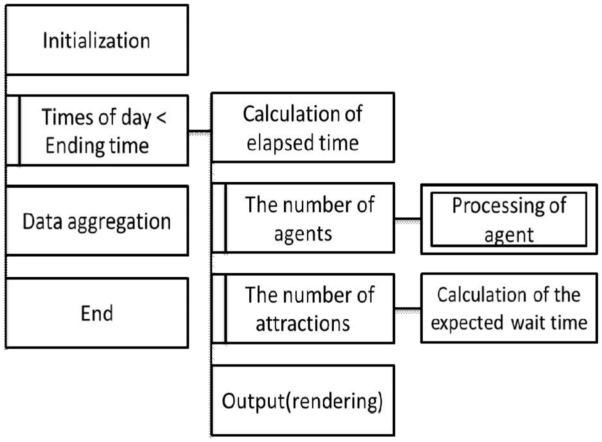

Fig. 1: Processing of this simulator

This simulator performs the processing in the following order.

・Initialization of each agent and each attraction

・Until and end times, and calculates the elapsed time

・Repeats the processing of agent only the number of agents

・The calculation of expected waiting time only, the number of attractions

・The drawing output

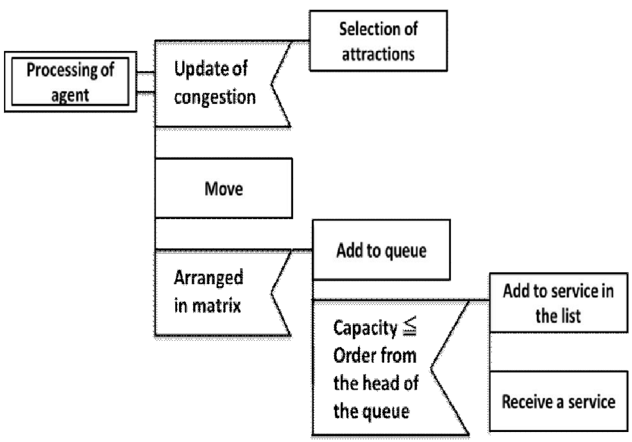

Fig. 2: The basic processing of agent

Treatment agents are as follows.

・If the updating of the congestion status has been carried out

・Make a selection of attractions that becomes the destination

・Move to the destination

・If you line up to queue to add to the queue

・When the turn comes added to in the service the list

・Receive a service

Theme park model

Attraction

Theme park (Tokyo Disneyland) consists of attractions and wall objects, we have set the 39 attractions. Set attraction

Fig. 3: Tokyo Disneyland Map

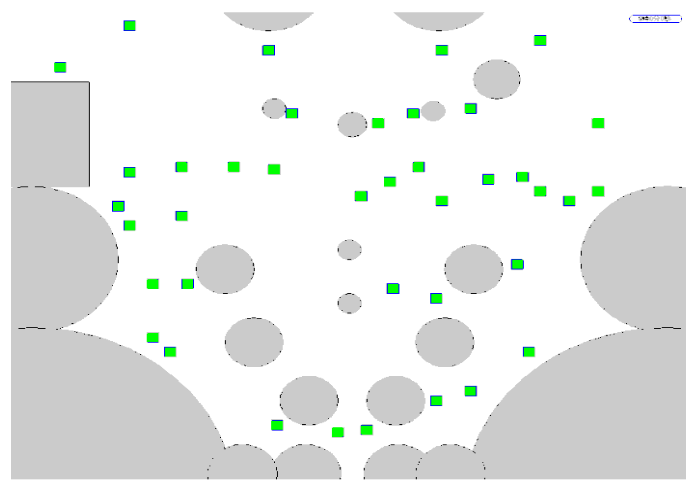

Fig. 4: theme park that was created

with the following as an attribute.

・Service time

・Popularity index

・Max persons

・Expected waiting time

・State (or not or in service)

It has. These attributes are set on the basis of the 39 attraction information of that real to Tokyo Disneyland.

How to obtain the expected waiting time, for example, a single ride time of approximately 3 minutes in 30 person occupancy when the Big Thunder Mountain an example, if 500 persons agent is present in the queue list, it becomes 17 times waiting in the queue list (500 people) ÷ Max persons (30 persons), determine the number of times that the attraction is wait movement. Then, ride time (3 minutes) × waiting times (17 times) the become 51 minutes of waiting time.

Furthermore, the list of the queue and in the service list and uses a linked list, a list of the queue and in the service list has a structure of a queue. Arrived in attraction, the agent is the order from the side by side in the queue was reproduced in the flow of the action between are waiting up to receive the

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service came around.

Fig.3 show actual map of the Tokyo Disneyland[8] and Fig.4 show created theme park model in this time. Around gray area shows the area that can not penetrate obstacles, green part is represented each attraction.

Moreover, attraction can be changed to red from yellow to yellow from green depending on the expected waiting time to represent the congestion situation has become easier to confirm the congestion degree as viewed from the user. In addition, the number of people waiting in the upper left corner of the attraction, is displayed in the lower left to the Max persons, the queue has become easier to see the congestion of each attraction are expressed.

Attraction of service time is to set the time it takes to once for every attraction, occupancy is set the maximum number of people can ride in one of the attractions.

Visualization

Visualization is present as a major element of this study.

Visualization of this simulator is obtained by drawing attraction, the agent, the obstacles to a frame that is generated. The user can observe the state of the park visualized. For the entire theme park and displays the current time in the simulator in the upper right corner, the expected wait time and status (in service or not in service) of each attraction by performing a re-drawing for each frame in the simulation there.

It is possible to confirm the congestion queue at each attraction by visualization, it is possible to see how congestion at a glance.

Fig.5 shows the state of the visualized queue. Agent is represented by a circle of red and blue, attraction is represented by green squares. Upper left to the current number of persons waiting (28 in Fig.5) attractions, indicated on the lower left capacity (80 in Fig.5). State of the queue can also be confirmed by visualization, it can be seen how the congestion. The agent is expressed gender respectively blue and red, that visit to a park agents gender but is random, it is possible to set parameters such as preference values in the future with the agent by gender, simulation by gender it also can be expected.

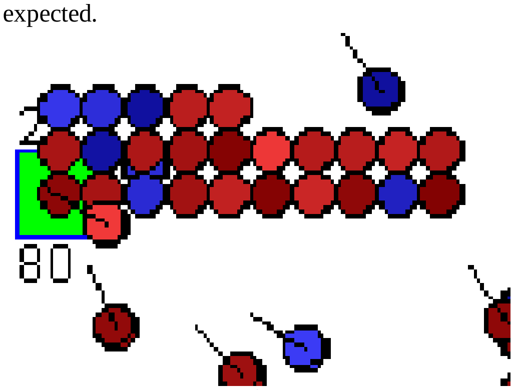

Fig. 5: State of the queue

Agent

The agent has as the following attributes.

・Attraction appetite

・More than once shunned value of going to the same attraction

・Shunned value to the matrix

・Time to be entering and leaving the park

・Number of times visited attraction

Agent is based on the preferences of attraction, move decided attraction toward, it is added to the queue if you decided to line up to the queue, are added to the service in the list, receive the service.

Probability $Pr_{ij}(t)$ that the agent j in time t to select the attraction i is determined by the formula(1). $Pr_{ij}(t)$ is determined by the proportion of each attraction in is the appetite $E_{ij}(t)$ .Then, the formula(2) seeking an appetite $E_{ij}(t)$ number of times and several times shunned value of going to the same attraction visited shunned value and attraction to the expected wait time and the matrix for the popularity index and preference value of the attraction, further it determined by the ratio of the sum of the distance between the agent and attractions.

$$Pr_{ij}(t) = \frac{E_{ij}(t)}{\sum_{k=1}^{N} E_{kj}(t)} \quad (1)$$

$$E_{ij}(t) = \frac{p_t+f_{ij}+1}{(q_{i(t)}\times c_j)+(v_{ij}\times a_j)+d_{ij}+1} \quad (2)$$

・$E_{ij}(t)$: Appetite for the attraction i of the agent j at the time t

・p_i : Popularity index of attraction i

・f_{ij} : Agent j of attraction i of preference value

・$q_{i(t)}$: Attraction i of the expected waiting time at the time t

・c_j : Shunned value to be arranged in a matrix of agent j

・v_{ij} : The number of times that the agent j visited the attraction i

・α_j : Shunned value of going to multiple times the same attraction of agent j

・d_{ij} : Distance of the agent j and attraction i

・N : Number of attraction

Popularity index of attraction, attraction of the year 2014 of average congestion time (time) through the one year and popularity to examine was determined by a value distributing based on the forward and congestion time. Shunned value of going to multiple times the same attraction is to represent the bored against attraction. Somewhat randomness as is because it determines the attraction the destination in preference We can reducing its potential little even by to have a bored for there is a possibility that in line and again to the queue for the same attraction. But, it may be a possibility arises alongside many times to the queue of the same attractions without getting tired by the agent. Therefore, we have to decide another attraction as a destination and bored little by little even for hard agents get bored let me remember the number of times visited the attraction.

Time to be entering and leaving the park are randomly set, the number of agents to visit to a park inputs when using the simulator number of agents varies with time rather than to the

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visit to a park at the same time, simulating the start gradually continue to congestion, the number of agents eventually to the visit to a park is you have to be a number of agents that have the input when using the simulator. Since the time that the agent entering and leaving the park is random, present in the agent also that in the middle exit park, only the number of agents that are present in the theme park is not increased so as to increase or decrease.

Preference value and each shunned value is a random value on each agent between 0.0 and to 1.0. That shunned value high agent is wait it becomes that hate agent. Furthermore, a preference value by a random value, it becomes the higher the ratio of selecting the popular attractions when viewed as a whole agent, where waiting hate agents presented congestion information is a destination attraction for the matrix and it can be moved toward another of the visited like attraction without arranged in hate matrix by allowing re-selected based on such shunned value. Thereby, theme park overall congestion situation, that is other attraction to have a significant impact on generates another queue whether, or maybe preference value exceeded the shunned value to and aware to the queue that the wait other attractions alongside effect on it is possible to simulate whether such be small.

EXPERIMENT

Experimental content

In this simulator is set to one second in one frame simulator, as soon as it becomes entering and leaving park time agent with is each between from 8:00 is the opening hours until is closed down time 22:00, from the entrance of the theme park entering and walk out.

Set as to encourage the re-selection of attraction by updating the presentation of the congestion in the context of the presented congestion situation can be confirmed, for the entire agent we verify the change in average transfer time or the average waiting time.

Also, because this experiment is to make in the context of all the park visitor person to check the congestion situation, as the same number of people to check the congestion situation and park visitor number as an input necessary for the experiment, it was Tokyo Disneyland assumed a model it was set 50,000 person of average park visitor number. Therefore, change the value of λ is the time interval for presenting the congestion information of attraction to the agent, and performs verification. Also, we went to verify the change of the number of times that received the service is the average of the total number that were riding on the attraction of each time interval for presenting each congestion information to the agent. $\lambda = 1$ is 100 seconds(100 frames) in the simulator .

Experimental results and discussion

Fig.6 showing a part of the execution screen. Attractions and agent and obstacles are represented wall objects, agent (customer) in red and blue is expressed. Then, appears waiting persons and Capacity for attraction is represented a queue that has been generated for the attraction.

Fig.7 is one of the experimental results, we show change in average transfer time and average waiting time of each production time. Horizontal axis in the graph is time in presented the time interval in the real a $\lambda \times 100$ seconds, ∞ has become a value when the congestion situation of the attraction agent is also not confirmed one person. And the vertical axis is the time(minutes), we respectively represent the average transfer time the red line graph, the average waiting time the blue line graph.

The Fig.8 show the change in the number of served at each production time. The horizontal axis of the graph is expressed in the same units as in Fig.7, the vertical axis represents the number of times received the service. The number of times that received the service has become a mean of the values of per person obtained from the total number who received the entire service.

If the average waiting time to be to shorten the interval time to be presented the attraction of congestion information from experimental results were reduced. However, the average transfer time is increasing. Also, the average transfer time is reduced and the interval time becomes longer, the average waiting time is long. When the average transfer time is longer than this thing, that is, when the value of λ is small, the fact that the average waiting time is shortened, the agent frequently by the updated congestion information selection of attractions is also frequently done destination and made attraction is not fixed easily, and they have become a state that is back and forth the theme park. The acquired information is considered to be much confusion they have occurred. Number of times throughout and take a look at the number of times that has received the service is small, have gone increasing the number of times little by little as the interval time will be longer.

Also, when the value of λ is large, the average waiting time become longer, the average transfer time is shortened. This agent than it arrived to attraction that becomes the destination earlier than to get the congestion information to be updated, while not know the congestion situation of other attractions, it is in a state in which they have lined up to queue became a purpose. Therefore it can be seen that and interval time take a look at the number of times that has received the service has dropped gradually as the number of times longer.

Pay attention about the number of times that received service the number of times of receiving the service as the highest has the time value of λ is 2.0.

However, when the value of λ is small case and large case we take a look compared to the time of ∞ that do not check the congestion situation of attraction in either. Then when ∞ is longer than the average wait times when which the average waiting time is shorter than any average transfer time average transfer time. In other words, in case you do not want to see the congestion information, because you do not know the whole of the congestion situation, select that line up to the matrix without directed to other attractions waiting time has gone longer. Also shows an overall small number but not said minimum is when the ∞ also the number of times of receiving the service.

May select a different attraction when the attraction of the waiting time it is trying to line up just before the presentation of the congestion situation has been increased than before. Gradually increasing transfer time by their frequency

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increases. It can be seen that the overall waiting time is increased and therefore would arranged in a matrix without considering the congestion just before by the interval presented opposite the congestion becomes longer.

In this setting from the above results, that the visit to a park guests everyone to the presented induce congestion situation in the situation to check the congestion situation did not lead directly to the elimination of congestion. From the congestion situation is presented with a congestion situation in a very short interval on the contrary, frequent the result of the number of times that the agent reach the first place to the attraction was extremely decreased by changing the destination of the agent you want to shunned that line up in particular matrix one after another with respect to the presentation of congestion, resulting information becomes large, considered is a possibility of confusion. However, for the agent intended to ride many attractions presented congestion information is considered to be effective. At that time as to update time interval of congestion information presented shorten the average transfer time and average latency, when the can was λ = 2.0 of be the most the number of times that received the service, that is congestion situation at 200-second intervals presentation of the it would be desirable.

CONCLUSION

In this report, we developed a pedestrians flow simulator for the theme park problem. This system is a multi-agent type simulator with the agent the visit to park visitors. Model regarded is the agent,

・Of agent, collision avoidance of the wall, and to have a judgment carrying left and right front, to avoid a collision if the obstacle is put in the area of the collision detection

・Agent does not proceed only in the direction that directed

・Select the attraction based on the value that is given as a congestion situation and parameters

It had to have features such as. Moreover, in setting the congestion status can be confirmed is posted to update the congestion information, and prompts the re-selection of attractions, shows the change in the average transfer time for the entire agent and the average waiting time. Further, it was also shown for changes in the number of served a number of previous riding attractions at that time. There by a change in the motion of the entire congestion and agent by the time interval of presentation appeared it has been confirmed.

The results of this study, that interval to present the congestion situation is presented in near real-time time interval, rather there is a possibility that led to confusion to the guest. Also in addition, induction by presentation of congestion has been found that not necessarily lead to the elimination of congestion. However, carrying out the presentation of the congestion at reasonable time intervals can be expected to be effective for the guest to want to ride a number of attractions.

The future prospects, it is planned to carry out the verification by the review and implementation and scenarios of various environment to inductive methods other than the posting of the congestion situation.

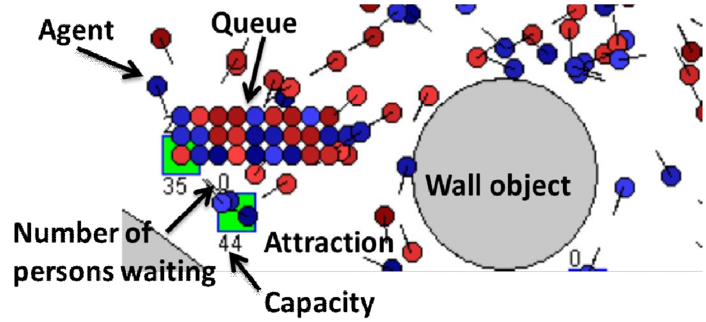

Fig. 6: run screen

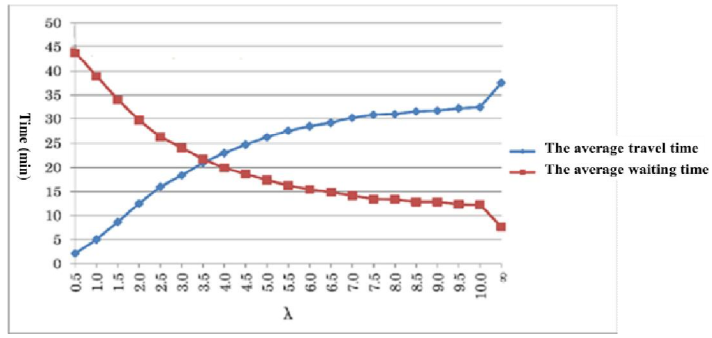

Fig. 7: change in the average transfer time and average waiting time

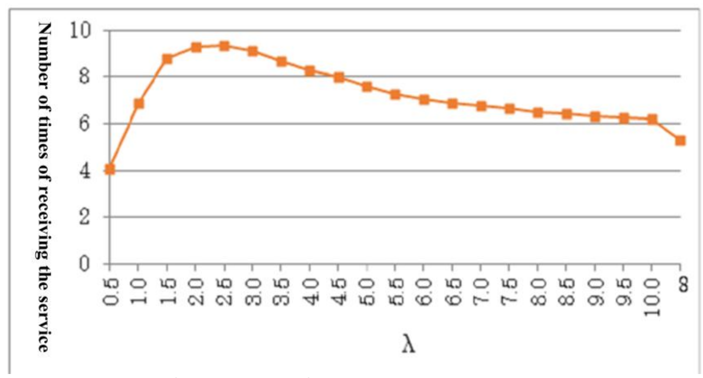

Fig. 8: change of the number of times that received the service

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