Study on Vehicle Scheduling Algorithms for Logistics Operations Based on Cloud Computing and Neural Network

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Abstract
This paper studies on methods taken in optimizing the existing vehicle scheduling problems in logistic operations. This paper proposes a new vehicle scheduling algorithm based on Cloud Computing and Neural Network to meet quality requirements and customer satisfaction which cannot be done by applying algorithm based only on Cloud Computing. The new algorithm made a parameterized settling model, taking all the service quality and the user’s satisfaction into consideration, to calculate the overall satisfaction on various resources, and then assign them to meet every user’s needs, so as to achieve an equilibrium resource execution. The application of the improved neural network will accomplish the vehicle scheduling. The result of the test for the models above shows that the new algorithm can meet various user’s needs to improve their satisfaction, and meanwhile to improve the resource distribution rate as well as the system resources utilization frequency.

Keywords: Cloud Computing, Logistics, Vehicle Scheduling, User Satisfaction, Neural Network

1. Introduction

Urban logistics is mainly a downtown-area goods delivery, which plays an important role in sustaining the city normal operation, so as in ensuring the citizen of their daily life. To the opposite, the dispatch of the goods brings the city some negatives such as the traffic jam and environmental pollutions, and so on. With the development of electronic commerce [1], and the general promotion of its production and operation mode featured a low inventory and an on-time delivery, a large number of frequent and small-scale delivery services have been generated, which resulted in low load rates and logistics inefficiencies. Thus, a further study how to protect the city with normal logistics by minimizing the negative impact while improving its efficiency matters a lot [2].

Cloud Computing is developed on the basis of the grid computing, distributing computing and parallel computing, which packaged various Internet centered resources for outside services offering. The users can buy such Cloud Computing services from a platform provider or a third party, and if the services the user bought are not to his satisfaction, he can turn to other providers for the services in need. This commercial feature limits its focus on providing users a variety of available resources and services, its resource allocation meeting kinds of requirements. In order to ensure the users of better services and higher satisfaction, a common resource allocation strategy and operation algorithm is needed [4]. The traditional resource allocation strategy and operation algorithm has a higher efficiency while it may cause an unbalanced system load for the resources of better computing capability being of higher occupation frequency, and neglect the requirements for service quality and satisfaction in proportion.

To address the above issues, this paper proposes a new vehicle-scheduling algorithm in logistics operations based on Cloud Computing and Neural Network. The new algorithm made a parameterized settling model, taking all the service quality and the user satisfaction into consideration, to calculate the overall satisfaction on various resources, and then assign them to meet every user’s needs, so as to achieve an equilibrium resource execution, and to optimize vehicle scheduling within an improved neural network, and finally to conduct a Cloud Computing simulation test on the platform of CloudSim. The result shows that the new algorithm can meet various users’ needs to improve their satisfaction, and improve the resources distribution rate as well as the system resources utilization frequency.
2. Analyses on Principles of Vehicle Scheduling in Logistics Operations

Vehicle scheduling problems can generally be divided into several categories in terms of their features. According to different transporting tasks, the problems can be divided into Loading Problems, Non-loading Problems, and Mix-dumping Problems, of which the third kind refers that in the transportation the problems are of not only loadings but also un-loadings. According to different loaded situations, the problems can be divided into Loaded Problems and Non-loaded Problems. The former refers that the loading weight has surpassed the car capacity, and the accomplishment of the task needs more transport cars. Non-loaded Problems refers that the car capacity is greater than the cargo, and one single vehicle can finish the task. In terms of the optimization objectives, the problems can be divided into Single-objective Problems and Multi-objective Problems, among which the former refers that there is only one most optimized indicator while the later a group of optimized indicators, such as a requirement of the shortest path at the lowest cost in a same transport.

The practical vehicle scheduling problems in logistics operations occur simultaneously one with another or even more, which makes the problem a multi-objective scheduling optimization problem for multi-delivery loaded multi-vehicles, belonging to the NP Problem, and the difficulty increases greatly while the time spending for computing gained exponentially. At present there is no exact solution algorithm for NP Problems. With the increase of the vehicle optimization problem, the exact algorithm size for computing increases exponentially. When the stop-for-unloading number is more than 20, time spent for calculating a shortest path with the application of a general exact algorithm will be more than 20 hours. Thus the paper concludes that the exact algorithm is not suitable for solving practical large-scale vehicle scheduling problems.

3. Algorithms for Scheduling Logistics Tasks Based on Cloud Computing and Neural Network

Cloud Computing is an emerging shared infrastructure, and its principle of distributing the huge storage and computing processes to numbers of non-local or remote services in the distributed computers through the computer network, which provides services and allows the users to switch resources to the applications in need. Cloud computing virtual manages and schedules both hardware and software resources to form a large virtual resources pool to collect the large amount of information and processor resources on personal computers, mobile devices and other equipment for a co-operation. This virtual Cloud Computing technology simplifies scheduling operations and resources allocation processes, and leaves the original complex vehicle scheduling problems in grid-scheduling operation to that of the virtual technology [6].

Cloud Computing provides services for various users on the Internet to meet needs of different users. Different users prefer different resources, some prefer real-time guarantee, some prefer lower costs, and some others prefer a strong support of stability. Different quantitative evaluation criteria are needed for different users according to different QoS parameters to measure user satisfaction.

Given the user submitted \(n\) tasks in Cloud Computing system which can provide \(m\) heterogeneous resources in corresponding. In this system, “\(a\)” and its relevant parameters refer to service quality and its satisfaction, and the user tasks, needs, and all service capability in responding to the resources in the system can be described as an “\(a\)” group \(B = \{X_1, X_2, \ldots, X_a\}\). Because the requirements for different users of their service qualities vary, some standardization should be taken in order to uniform requirements for service quality and the resource service capacity of all dimensions. The matrix \((n+m)\times a\) refers to a combination of the requirements for service quality and the resource service capacity of each user, and vector \(b_{i,a}\) refers to the parameters in row \(i\) and in line \(a\) in the matrix.

In different definitions and implementations, different parameters have different forms of expression and ranges of values. In order to conduct a comprehensive evaluation, all parameters...
need to be normalized to limit all parameter values in $[0, 1]$. The method of normalization can be used as follow: given in the matrix the maximum value in line $a$ is $\max b_a$, and the minimum $\min b_a$. $c_{i,j}$ refers to the normalized parameter values, $b_{i,j}$ refers to the current value, then the normalized matrix can be expressed as [8]:

$$c_{i,j} = \begin{cases} \frac{b_{i,j} - \min b_a}{\max b_a - \min b_a} & \text{if } \max b_a \neq \min b_a \\ 1 & \text{if } \max b_a = \min b_a \end{cases}$$

(1)

In which, $i = 1, 2, 3, \ldots, m + n; j = 1, 2, 3, \ldots, a$. Obviously, in condition of ensure a proper linear relationship, the above formula limits the values in the range of $[0, 1]$. In normalized parameters, the resources satisfaction of different users can be calculated with the formula as follow:

$$d_{i,a} = \begin{cases} C_{r,a} & C_{r,a} < C_{i,a} \\ 1 & C_{r,a} > C_{i,a} \end{cases}$$

(2)

By using this formula, when $0 \leq d_{i,a} \leq 1$, the value of the vector $C_{i,a}$ indicates the resource service capacity provided for $a$ by the system, and the value of the vector $C_{r,a}$ indicates the resource service capacity needed for $a$ by the system.

The overall satisfaction for all resources users can be expressed as [9]:

$$S_i = \sum_{j=1}^{a} \alpha_j d_{i,j}$$

(3)

By using this formula, when $0 \leq S_i \leq 1$, refers to the weight vector of the resource parameters, a refers to the number of resources a user requires, the higher the value of $S_i$, the higher of the user satisfaction and the resources service capability, which, of course, will generate low QoS task occupying high QoS resources service capacity, and affect the execution of other tasks, which is referred to as load balancing problems in Cloud environment. Operation scheduling mechanism for user satisfaction accomplishes the optimal allocation of the tasks and resources, while its algorithms target better. For example, the operation-scheduling algorithm targeted a minimal accomplishment time will make the resources of better computing capability frequently occupied while the one of weak computing capability idled, and lead to decreased resource utilization and load concentration and other problems. In this reason the algorithms applied in this paper also consider the load balance problems.

On the premise of ensuring customer satisfaction, this paper compares the resources service capabilities the system can provide with the service capability for system users of the resources needed to calculate the Euclidean distance between the two. The result shows the shorter the distance is, the more stable it is, and the performance ratio meets the needs of users most.

Suppose vector $X = \{X_1, X_2, X_3, \ldots, X_n\}$ and vector $Y = \{Y_1, Y_2, Y_3, \ldots, Y_n\}$ of the Euclidean distance is calculated as:

$$D = \sqrt{(X_1-Y_1)^2+(X_2-Y_2)^2+\ldots+(X_n-Y_n)^2}$$

(4)

The distance between the comprehensive QoS resources service capabilities and comprehensive user QoS requirements can be calculated according to the formula above.

By using this formula, when $0 \leq D \leq 1$, refers to the weight vector of the resource parameters, a refers to the number of resources a user requires. If one user task obtains the highest overall satisfaction in certain resource and such resource tops all the other ones in getting the overall satisfaction and has a minimal task occupation of $D$ resource, this indicates that the system, on premise of ensuring the user satisfaction, in order to make the overall resources of balanced
occupation, and achieve the user’s preferred expectations for its performance, assigns the tasks to
resources separately for execution.

3.2 Logistics Operations Solutions Based on Neural Network for Vehicles Distribution

To ensure the output energy an effective transportation matrix on a stable network state, the
network must be within the following constraints:

(1) A Constraint on an Available Valid Path

In order to prevent a non-existent path being selected, a constraint function should be operated
as follow:

\[ \rho_{x,i} = \begin{cases} 1 & \text{Margin}(x,i), \text{Unavlabel} \\ 0 & \text{Others} \end{cases} \]  

(5)

(2) Constraints on Input and Output Paths

In order to ensure an input path for the network node, there must be an output path. A
constraint function should be operated as follow:

\[ E_2 = \frac{u_2}{2} \sum_{x=1}^{n} \sum_{i=1}^{n} |V_{xi} - V_{de}| \]  

(6)

where \( u_2 \) refers to a Penalty Factor.

(3) To ensure the state of the network can be converted to a hypercube, a constraint function
should be operated as follow:

\[ E_3 = \frac{u_3}{2} \sum_{x=1}^{n} \sum_{i=1}^{n} V_{xi} (1 - V_{xi}) \]  

(7)

where \( u_3 \) refers to a Penalty Factor.

(4) In order to ensure a shortest path with a regulated starting point, referred as \( s \), and a
regulated terminating point, referred as \( d \), thus a constraint function should be operated as
follow:

\[ E_4 = \frac{u_4}{2} (1 - V_{de}) \]  

(8)

where \( u_4 \) refers to a Penalty Factor.

Then to determine the objective function, Neural Network objective function is:

\[ E_5 = \frac{u_5}{2} \sum_{x=1}^{n} \sum_{i=1}^{n} C_{xi} V_{xi} \]  

(9)

where \( u_5 \) refers to a Penalty Factor.

Energy function for Neural Network can be expressed as:

\[ E = E_1 + E_2 + E_3 + E_4 + E_5 \]  

(10)

Each neuron output can be expressed as:

\[ \frac{dU_{xi}}{dt} = - \frac{U_{xi}}{t} - \frac{\partial E}{\partial V_{xi}} \]  

(11)

So the motion equation in this vehicle-scheduling model can be expressed as:
\[
\frac{dU_{\omega}}{dt} = -\frac{U_{\omega}}{t} - \frac{u_s}{2} \bar{d}_s (1 - \delta_{\omega}\delta_{s}) + \frac{u_1}{2} \rho_{\omega} (1 - \delta_{\omega}\delta_{s}) - u_2 \sum_{y=1}^{a} (V_{xy} - V_{yx})
\]
\[
(12)
\]
where \(\delta_{a,b}\) is defined as:
\[
\delta_{a,b} = \begin{cases} 
1 & a = b \\
0 & \text{Others}
\end{cases}
\]

Take Equation (10) into Equation (12), the equation for motion neural network is obtained as:
\[
\forall(x \neq i), \forall(y \neq i)(13)
\]

Comparing the co-efficiencies in Equation (12) and Equation (13), the connection weights and the bias current \(I_{\omega}\) can be obtained as:
\[
I_{\omega} = -\frac{u_s}{2} \bar{d}_s (1 - \delta_{\omega}\delta_{s}) + \frac{u_1}{2} \rho_{\omega} (1 - \delta_{\omega}\delta_{s}) - u_2 \sum_{y=1}^{a} (V_{xy} - V_{yx}) = \frac{u_4 - u_3}{2} + \frac{u_4}{2} \delta_{sd} \delta_{s}\]
\[
(14)
\]

If \((x, i) = (d, s)\)
\[
\begin{cases} 
\frac{u_4 - u_3}{2} \\
-\frac{u_s}{2} \bar{d}_s - \frac{u_1}{2} \rho_{\omega}
\end{cases} \quad \text{Others}
\]

When the Neural Network tends to be stable, an optimized solution, which refers to the result of the shortest path, can be obtained.

### 3.3 Steps in Scheduling Algorithm

Scheduling algorithm is fully taken into account the quality of service and customer satisfaction, create a parameterized process model to calculate the user in various resource for overall satisfaction, then the task assigned to meet user needs and system resources to run a balanced resources, assign tasks to the resources of system resources on a balanced one, and finally the adoption of improved neural networks to optimize the vehicle scheduling.

1) Line the input user tasks according to their priority from a high degree to a low one;
2) Parameterization of the resources required by the users and provided by the system should be accomplished, and weight vectors for users' resources should be determined;
3) Normalize the parameters, and to calculate the overall user satisfaction on different resources;
4) Generate a candidate resources collection based on overall satisfaction and then line according to degrees;
5) Compare the service capacity between the resources that the system can provide and the ones the users needed in the candidate resources collection, and then calculate their Euclidean distance.
6) Choose the resource with minimal Euclidean distance in the candidate collection, and assign the task on the selected resource for execution.
7) Adopt the improved neural network algorithm to optimize the vehicle scheduling.

The algorithm above, which runs the system on a balanced occupation, chooses resources of a
minimal Euclidean distance to achieve a reasonable choice for resources instead of the ones with maxim parameters which may cause a waste, while it also ensures a good user satisfaction.

4. Results and Analysis

Cloud Computing Platform CloudSim is implemented for a simulation experiment, and a scheduling algorithm in its source code based on service quality and satisfaction has been obtained, while a simulation program for the algorithm on an extended platform has been re-compiled. Given the system set the weight vector according to the user tasks as vector \( W = [0.6, 0.2, 0.1, 0.1] \), in which the first dimension is a CPU number weight vector, the second the memory, the third the bandwidth, and the fourth the security, the test finds that this task requires a high computing capacity. Here is a comparison of optimal completion times for scheduling algorithm optimization between Neural Network and Cloud Computing tasks with CloudSim of current scheduling policy as shown in Figure 1, and the comparison of user satisfaction between shown in Figure 2.

![Figure 1](image1.png)

**Figure 1** the Comparison of Execution Time between Two Algorithm-Tasks

![Figure 2](image2.png)

**Figure 2** the Comparison of Satisfaction between Two Algorithm-Tasks

Through a comparative analysis, the paper concludes that Figure 1 shows the comparison of execution time between two algorithm-tasks in which Figure 2 shows the comparison of satisfaction between two algorithm-tasks. In Figure 2, the user satisfaction in Task 2 and Task 3 reaches 1 which indicates that the user obtains the expected resources. In this term, the paper has proposed a vehicle scheduling algorithm in logistics for a better resources allocation in line with user expectations to improve user satisfaction. Moreover the algorithm can improve the resources distribution rate and the overall system resources utilization frequency.

5. Conclusions

This paper studies on methods in dealing with the vehicle scheduling problems in logistic operations. This paper proposes a new vehicle scheduling algorithm combining Cloud Computing with Neural Network by analyzing the user satisfaction, which provides fair
obtaining chances for various users of different requirements. The application of the new algorithm can improve the user satisfaction for its meeting various users’ needs, so as to improve the resources distribution rate and the overall system resources utilization frequency.

6. References