Fast update method of new equipment status in IMS network based on ant colony optimization algorithm

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Abstract. In order to update the status of new equipments in IMS network quickly, a new method based on ant colony optimization algorithm is studied. This method is to lock the new status of IMS network and establish the location model of new equipment in IMS network. For the new equipment in IMS network that has been located, the load balancing method of new equipment in IMS network based on ant colony optimization algorithm is adopted to obtain the optimal operation state of new equipment in IMS network, and realize the rapid update of new equipment status in IMS network. The experimental results show that: the proposed method can accurately locate the coordinates of new equipments in IMS network when the node regularity is significant or not; it can effectively improve the update speed of new equipments in IMS network, and realize the rapid update of new equipment status in IMS network; the negative impact on IMS network is smaller, and under the premise of small and large load of IMS network, the proposed method can improve the performance of IMS network. When the new IMS network adds new equipment status, the false alarm rate is small and the update result is reliable.

1. Introduction
The fluency of IMS network communication has a direct impact on its service quality[1-3]. When new equipment appears on the IMS network, if a reasonable network communication resource scheduling is not realized, the newly added equipment will be congested in network communication [4]. For this reason, the rapid update of the status of newly added equipments in the IMS network has an important impact on the quality of service of the IP multimedia subsystem. The ant colony optimization algorithm has significant performance such as collaboration, robustness and scalability. It has a good application effect in a dynamically changing environment. Therefore, this paper proposes a rapid update method for the status of newly added IMS network equipment based on the ant colony optimization algorithm. This process can improve the efficiency of updating the status of newly added equipments in the IMS network.

2. Rapid update method of new equipment status in IMS network based on ant colony optimization algorithm
2.1. New equipment status in IMS network
The positioning of the coordinates of the newly added equipment in the IMS network is a prerequisite for achieving the rapid update of the status of the newly added equipment in the IMS network. It can shorten the time-consuming to update the status of new equipment in the IMS network.
When locating newly added equipments in the IMS network, the distance between the IMS network routing equipments is first detected and located. The newly added routing equipment of the IMS network that needs to be located is set to \( E(x) \). There are \( m \) routing equipments in the IMS network, and the distance matrix between routing equipments in the IMS network is:

\[
E(x) = \begin{bmatrix}
0 & e_{12} & e_{13} & \cdots & e_{1m} \\
e_{21} & 0 & e_{23} & \cdots & e_{2m} \\
e_{31} & e_{32} & 0 & \cdots & e_{3m} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
e_{m1} & e_{m2} & e_{m3} & \cdots & 0
\end{bmatrix}
\] (1)

If the newly added routing equipment in the IMS network is in the \( m \)-dimensional space, there is one ID for the newly added routing equipment in the IMS network. The coordinate of the newly added routing equipment is \( Y = (y_1, y_2, \ldots, y_m) \). Then the coordinates of all routing equipments in the IMS network are \( Y = (Y_1, Y_2, \ldots, Y_m) \).

The \( h \)-dimensional spindle coordinate solution is:

\[ Y^h = U_h \Omega_h \] (2)

The newly added routing equipment in the IMS network is retrieved in the \( E \)-dimensional space. There are \( m \) routing equipment particles in the initial population. The routing equipment particle \( j \) in the population can be described as \( Y_j = (y_{j1}, y_{j2}, \ldots, y_{jm}) \). The particle position of this routing equipment is set to \( Q_j \):

\[ Q_j = (q_1, q_2, \ldots, q_m) \] (3)

Then the positioning method of the newly added routing equipment is:

When the position of the newly added routing equipment is located, the first fitness function and the second fitness function must be constructed. The real distance from the coordinate of the beacon routing equipment to the coordinate of the newly added routing equipment in the IMS network is set to \( z_{jm} \). The positioning error interval is \( \theta_m \). \( e_{ji} \) is the distance between IMS network routing equipment \( j \) and \( i \). The constraint condition of the newly-added routing equipment coordinate in IMS is:

\[ e_{ji}^2 - \theta_i^2 \leq \left( (y_j - y_i)^2 + (x_j - x_i)^2 \right) \leq e_{ji}^2 + \theta_i^2 \] (4)

By formula (6), the minimum local target cost function of the newly added routing equipment coordinates in IMS can be obtained:

\[ R_j = \sum_{i=1, \forall i \neq j}^m \zeta_{ji} (z_{ji} - e_{ji})^2 + 2 \sum_{i=m+1}^M \zeta_{ji} (z_{ji} - e_{ji})^2 \] (5)

Among them, \( M \) is the number of routing equipments in the IMS network. \( m \) is the number of newly added routing equipments in the IMS network. If the routing equipments \( j \) and \( i \) in the IMS network belong to neighboring equipments, the distance between the routing equipments \( j \) and \( i \) in the IMS network is \( e_{ji} \). Otherwise, the value of \( e_{ji} \) is 0. The weight is set to \( \zeta_{ji} \). If the routing equipments \( j \) and \( i \) in the IMS network do not have distance measurement values and do not belong to neighboring equipments, then the weight value is not equal to 0.

The value obtained by using the above formula is the equipment coordinate \( f_j(x_j, y_j) \), and the constraint expression can be transformed into:
\( F_j(x_j, y_j) = \frac{\exp(Q_m(x_m, y_m) - f_j(x_j, y_j))}{z_{ji}} \)  \hspace{1cm} (6)

\( F_j(x_j, y_j) \) is the optimized new equipment coordinates in the IMS network.

### 2.2. Load balancing method of newly added equipment in IMS network based on ant colony optimization algorithm

This algorithm is used in the problem of updating the status of new equipment in the IMS network, and a load balancing method for new equipment in the IMS network based on the ant colony optimization algorithm is proposed. The load situation of the newly added equipment in the IMS network is reasonably balanced and scheduled to realize the rapid update of the status of the newly added equipment and ensure the normal operation of the IMS network.

Algorithm input: The new device status update task set in the IMS network is set to \( H = \{h_1, h_2, \ldots, h_m\} \). The IMS network routing device set is \( F = \{f_1, f_2, \ldots, f_n\} \). The ant colony is \( B_{mt} \). The size of the ant population is \( G \). The maximum number of iterations is \( J_{\text{max}} \). The weights of the objective function of the new equipment status update of the IMS network are \( \xi_1, \xi_2, \xi_3, \text{ and } \xi_4 \). Added equipment selection probability parameters \( c \) and \( d \). Pheromone volatilization rate is \( \epsilon \).

Algorithm output: a vector of \( 1^*m \). Each component value of the vector corresponds to the code assigned to a new device in the IMS network;

Initialization: The number of initial iterations is set to 1;

### 3. Experimental analysis

#### 3.1. Experimental setup

The configuration of the computer used in the experiment is: The simulation is implemented through MATLAB7.1. 200 routing devices are set to be randomly distributed in an interval of 300m*300m.

#### 3.2. New equipment positioning performance experiment

In the environment where the regularity of the nodes is significant and not significant, 8 routing devices are added respectively to test the performance of the method in this paper. The results are shown in Table 1.

| Newly added routing device code | Significant regularity of IMS network nodes Positioning coordinates of the method in this paper/m Actual coordinates/m | The regularity of IMS network nodes is not significant Actual coordinate/m Positioning coordinates of the method in this paper/m |
|---------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| f1                              | (79,60) (79,59.7)                                                                                   | (22,32) (22,32)                                                                                  |
| f2                              | (57,77) (57,77)                                                                                    | (24,17) (24,17)                                                                                  |
| f3                              | (35,66) (35,66)                                                                                    | (45,65) (45,65)                                                                                  |
| f4                              | (20,38) (20,38)                                                                                    | (178,142) (178,142)                                                                             |
| f5                              | (16,35) (16,35)                                                                                    | (116,135) (116,135)                                                                             |
| f6                              | (57,57) (56,7,57)                                                                                  | (97,57) (96,57)                                                                                  |
| f7                              | (13,43) (13,43)                                                                                    | (63,43) (63,43)                                                                                  |
| f8                              | (34,44) (34,44)                                                                                    | (34,84) (34,84)                                                                                  |

By analyzing the data in the table 1, it can be seen that in the IMS network environment where the regularity of nodes is significant and insignificant, the error between the positioning results and the
actual coordinates of the eight IMS network newly added routing device coordinates is ±0.3m. The positioning error is within an acceptable range. The method in this paper can accurately locate the coordinates of newly added equipment in the IMS network.

3.3. Update effect of newly added device status

In order to test the effect of the method in this paper on the status update of the newly added routing equipment in the IMS network, the load balance dispersion is used as the evaluation index. The higher the load balance dispersion, the higher the network congestion of the newly added equipment in the IMS network. The load balance dispersion is small, and the IMS network has a high degree of network smoothness. Its load rate is low. The calculation method of load balancing deviation is:

$$\rho = \sqrt{\sum_{m=1}^{m} \left( \hat{\Gamma}_i - \bar{\Gamma}_i \right)^2} / (m-1)$$ (7)

Among them, \( \hat{\Gamma}_i \) and \( \bar{\Gamma}_i \) respectively represent the IMS network load level before and after use. \( m \) represents the number of updates. \( i \) represents the number of newly added routing devices.

Table 2 shows the calculation results of load balance dispersion before and after the IMS network uses the method in this paper.

| Number of newly added routing devices | before use | After use | Dispersion |
|--------------------------------------|------------|----------|------------|
| 1                                    | 0.3254     | 0.1003   | 0.2251     |
| 2                                    | 0.3651     | 0.1001   | 0.2650     |
| 3                                    | 0.4012     | 0.1234   | 0.2778     |
| 4                                    | 0.2935     | 0.0984   | 0.1951     |
| 5                                    | 0.2546     | 0.1024   | 0.1522     |
| 6                                    | 0.2345     | 0.0942   | 0.1403     |
| 7                                    | 0.2674     | 0.0987   | 0.1687     |
| 8                                    | 0.3543     | 0.0963   | 0.2580     |

By analyzing the data in the table 2, it can be seen that the load balance deviation of the IMS network after using the method in this article is lower than before. The maximum reduction is 0.2778. This means that after using the method in this article, the IMS network has a higher patency and a lower load rate.

The IMS network uses the method in this paper before and after the new device status update delay situation is tested. The result is shown in Figure 1. The calculation method of time delay is:

$$pl = \int_{\infty}^{t} t \xi (t, F) \, dh / \int_{\infty}^{\infty} \xi (t, F) \, dh$$ (8)

Among them, \( t \) represents the time, and the output result of the new device status update of the IMS network is \( \xi (h, F) \, dh \).

As shown in Figure 1, after the method in this paper is used, the maximum delay of the new device status update in the IMS network is 1.2545s. Compared with the time delay before use, the maximum reduction value is 4.2655s. It can be seen that the method in this paper can effectively improve the update speed of newly added equipment in the IMS network, and realize the rapid update of the status of newly added equipment in the IMS network.
The calculation method of the bandwidth utilization rate $\mu$ and the packet loss rate $d$ of the IMS network after using the method in this paper is:

$$\mu = \frac{\delta}{\delta \times t}$$

(9)

Among them, $\delta$, $\delta$, and $t$ are the total traffic value, theoretical bandwidth and time of the IMS network, respectively.

$$d = \frac{w_1 - w_2}{w_1}$$

(10)

Among them, $w_1$ and $w_2$ are respectively the total value of the number of times that the IMS network sends packets and the total value of the number of times that the response is received.

When the number of newly added routing devices in the IMS network gradually increases, the calculation results of the bandwidth utilization and packet loss rate of the IMS network after using the method in this paper are shown in Figure 2 and Figure 3.
By analyzing Figure 2 and Figure 3, it can be seen that after using the method in this paper, the maximum IMS network bandwidth utilization rate is 0.96, and the maximum packet loss rate is only 1.35%. The method in this paper has very little negative impact on the IMS network, and can be used in the status update of new equipment in the IMS network.

Under the premise that the load of the IMS network is small and the load is large, the effect of the new equipment status update before and after the IMS network using the method in this paper is tested. The update effect is judged by the false alarm rate, and the judgment result is shown in Table 3. The method of calculating the false alarm rate is:

$$w_0 = \left| \Gamma \right| - \left| \Gamma \cap \Psi \right| / \left| F \right| - \left| \Psi \right|$$  \hspace{1cm} (11)

In formula (14), the state of all devices in the IMS network is described as $F$. The actual newly added device status and the newly added device status updated by the method in this paper are $\Psi$ and $\Gamma$ respectively.

| Newly added routing device code | Traditional algorithm | False alarm rate% |
|--------------------------------|-----------------------|-------------------|
|                               |                       |                   |
| f1                             | 1.32                  | 0.02              |
| f2                             | 1.22                  | 0.04              |
| f3                             | 1.28                  | 0.05              |
| f4                             | 1.31                  | 0.01              |
| f5                             | 1.21                  | 0.02              |
| f6                             | 1.30                  | 0.04              |
| f7                             | 1.22                  | 0.05              |
| f8                             | 1.24                  | 0.07              |
| f9                             | 1.27                  | 0.08              |
| f10                            | 1.31                  | 0.09              |

By analyzing Table 3, it can be seen that the false alarm rate is different under different nodes. For node f1, the false alarm rate of the traditional algorithm is 1.32%, and the false alarm rate of the ant colony optimization algorithm is 0.02%. For node f3, the false alarm rate of the traditional algorithm is 1.28%, and the false alarm rate of the ant colony optimization algorithm is 0.05%. For node f8, the false alarm rate of the traditional algorithm is 1.24%, and the false alarm rate of the ant colony optimization algorithm is 0.07%. Under the premise that the load of the IMS network is small and the
load is large, the method in this paper has a small false alarm rate when updating the status of new equipment in the IMS network, and the update result is credible.

4. Conclusion

This paper proposes a method for quickly updating the status of new equipment in the IMS network based on the ant colony optimization algorithm, and implements the simulation experiment through MATLAB 7.1. The following conclusions are obtained: It is verified through testing that the positioning error of the method in this paper is within an acceptable range. Load balance deviation is lower than before use. The maximum value of the delay in updating the status of newly added devices in the IMS network is 1.2545s. The reduction value is up to 4.2655s. This method can increase the speed of updating the status of newly added equipment in the IMS network. This method has minimal negative impact on the IMS network. The false alarm rate is low.

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