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Methods of MP2P Network Task Co-allocationBased on IV-Vicsek Model

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Abstract

The present task allocation methods exists some problems, such as lower execution efficiency and poor consideration on mobility and security. Therefore, on the basis of MP2P network, the paper proposed a task allocation method based on modified Vicsek model in the view of cooperatives, security and mobility. From the contrast experiment with DFPSO and Random, we concluded that the average execution time delay of proposed method increased 17.6% on average than DFPSO. And the number of completed tasks increased 18.5% and 1 times than DFPSO and Random.

Keywords: *mobile peer-to-peer; WAR-Vicsek model; task co-allocation model; binary routing*

1. Introduction

The large-scale distributed mobile network completes complex tasks demandsmake full use of the processing capability and cooperation of nodes.The existing task allocation methodsof centralized mode have the problem of center node overload and single point of failure. Distributed task allocation methods improved these defects of centralized distributed task allocation methods. Su zhaopin [1] proposed a distributed multiple task parallel algorithms based on PSL. Nodes search task by self-organization and self-learning and distribute actual workload by communication and negotiation. Sun tingting [2] established the method of multi-agent system to implement the complex heterogeneous network resource allocation, and used distributed solution to solve the problem of the allocation of the whole heterogeneous resources from broad sense. The studies of the distributed task allocation put forward some solutions on disadvantages of centralized task allocation methods and achieved some results.Due to the distributed task allocation studiesarein the preliminary research stage, there are poor systematic research results. And the present studies mainly focus on fixed network infrastructure services; at the same time ignore the consideration of security of nodes. As a result, the processing result is not ideal.

The decentralizedfeature of MP2P [3] can provide foundation to solve the problem of a single point of failure in the process of task allocation for various applications such as battlefield situational awareness. And the direct interaction of peer nodes between each other can provide support for collaboration among various information processing nodes and make full use of the capability of each node [4].

Vicsek model is a swarm intelligence model, which describes birds with different initial flight direction via adjusting the flight direction each other to reach agreement in the end [5-6]. Due to tasks in collaborative allocation to achieve network load balancing has similarities

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with adjustment ofVicsek model, so combining Vicsek model and MP2P can apply in the distributed task co-allocation in mobile environment.

2. Related Studies

2.1. Model Mapping

The abilities of nodes are different in processing tasks in MP2P network and the allocation of tasks may also be different. However, when nodes are allocated a large number of tasks, nodes will be in a state of overload, which will cause execution speed decrease. Some nodes are in idle state, which cause waste of idle resources and reduce the overall efficiency of the system. Therefore, it needs to through task allocation method distribute the tasks of high load nodes to the surrounding relatively idle nodes, as far as possible to maintain the balance of task load of each node in network.

The task co-allocation proposed in this paper refers to when a node found itself does not have enough ability to deal with the current tasks or new tasks waiting to be processed, it need to be as a task distributor to realize the dynamic allocation and adjustment of each other through the coordination among the neighbor nodes, and then complete the task allocation. The adjustment the allocation process is similar to the adjustment process of birds flying in Vicsek model. The adjustment the allocation among nodes is similar to speed adjustment to avoid crash. The task load rate of each node tend to be consistent and have no conflict to each other on needed resources is similar to the final flight status with no crash each other. Therefore, in this paper the idea of motion state adjustments between individual is used on task allocation in network.

The adjustment process of nodes task allocation is shown in Figure 1. In the figure, the size of each grid denotes different node and the size of blank area denotes the load rate of nodes. The more blank area, the lower load rate that is the node is idler. The load state of each node before adjustment is shown in figure a. After task co-allocation, the load state of each node is shown in figure b. After adjustment there are no nodes with higher or lower load rate and the load rate tend to be same. To realize the task co-allocation and reach to the balance of task load, the core problem is to determine which nodes need to distribute and when to distribute.

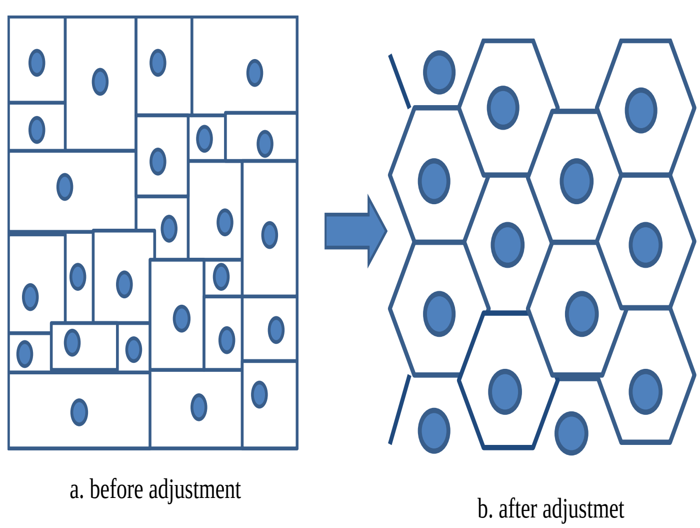

Figure 1. The Adjustment Process of Nodes Task Allocation

2.2. Disadvantages of Model Mapping

The nonlinear characteristic of Vicsek model makes theoretical analysis very difficult and the model is idealized. Many researchers modified the modelup till the present moment. Jadbabaie *et al.*, [7] built a linearVicsek model which effectively solved the synchronous relationship between the individual position and direction. Chen *et al.*, [8] proposed a modified model based on the biggest departure from the rules depending on Vicsek. WAR-Vicsek model considered that there is mutual influence weight only individual within the scope of neighborhoodandgather and separate rules of birds. In WAR-Vicsek model, birds adjust speed through gather and separate rules and the weighted average of other individual speed [9]. But the model still has certain restrictions in the actual process of adjustment. The model considered the impact from the distance of neighbor individual and ignored the size of individual. When the size of individual does not match with the leave space around, it is easy to cause crash in the process of adjustment, which will affect the group flight time finally needed forandreduce the convergence efficiency of the system.

To achieve task allocation, not only affected by the load condition of around nodes, but also the nature of the nodes limits the accuracy of task allocation scheme. Therefore, WAR-Vicsek model cannot be used in task allocation directly, so it needs to be modified.

3. Task Co-allocation Model

3.1. Vicsek Model based on Individual Volume Vicsek

This paper proposed a new modified Vicsek model based on individual volume (IV-Vicsek). The formalized definition of IV-Vicsek model is as follows:

The set consists of N agents in n dimensional space is denoted with S<X, P, V>. X=（$x_1,x_2,x_3 \dots x_i \dots x_N$）, $x_i \in R^n$ which is the position vector of agent *i*. P={ K,α,β } is the set of control parameters; V=($v_1,v_2,v_3,\dots,v_i,\dots v_N$) , $v_i \in R^n$ is the velocity vector of agent i; Vo=(vo_1, vo_2, $vo_3,\dots,\dots vo_N$), $vo_i \in R^n$ is the size of volume of agent *i*. The speed of an agent is controlled by formula (1).

$$v_i(t+1) - v_i(t) = \sum_{j \in N_i(t)}^{k} a_{ij}(v_j(t) - v_i(t)) \qquad (1)$$

Agent *i* adjusts its speed through weighted average between the difference with other agents' speed within the neighbor scope and its speed. a_{ij} is the effect weight of agent *j* to agent *i*. The weight computation formula is as follows.

$$a_{ij} = \eta(\| x_i - x_j \|^2) \qquad (2)$$

$$\eta(d) = \begin{cases} \dfrac{-K}{(\alpha^2 + d)^{\beta} \bullet (\alpha + Vo)^{\gamma}}, & 0 < d < r \\ \dfrac{K}{(\alpha^2 + d)^{\beta} \bullet (\alpha + Vo)^{\gamma}}, & r < d < R \\ 0, & \text{others} \end{cases} \qquad (3)$$

In formula (3), $d = \| x_i - x_j \|$ is Euclidean distance between two individuals in n dimensional space. *Vo* is the volume of a bird, *R* is radius of neighborhood, *r*is exclusive domain radius. $K>0$, $\alpha \geq 0$, $\beta \geq 0$, $\gamma \geq 0$ and $0 \leqslant K/(\alpha^2+d)^{\beta} \bullet (\alpha+Vo)^{\gamma} \leqslant 1$.The position of individual *i* at time t+1 is computed in formula (4).

$$x_i(t+1) = x_i(t) + v_i(t)\Delta t \qquad (4)$$

Δt is the actual time interval between t+1 and t. Individual adjusts its flight status through formula (1). The speed adjustment of individual depends on weight a_{ij}. In order to avoid speed increasing indefinitely, setting the value range of a_{ij} is (0, 1]. No matter how changes of K, α, β and γ, the value of weight still within the range.

3.2. Task Co-allocation Model based on IV-Vicsek Model

3.2.1. The Determination of Balance Status of Nodes

The load utilization rate is the ratio between the used processing capacities with total capacities of a node, denoted θ. The services of nodes are various, but different types of services with different resources. The processing capacities of nodesare mainly influenced by CPU, Memory and Storage [10].The processing capacity of a node is computed as formula (5).

$$S = S_{CPU} \times R_1 + S_{Storage} \times R_2 + S_{Memory} \times R_3 \, (5)$$

S_{CPU}, $S_{Storage}$, S_{Memory} denote the service capacities of a node in CPU, Memory and Storage. R_1, R_2 and R_3 are the weight of the three factors, and $R_1 + R_2 + R_3 = 1$.

In the initial state, the processing capacities of nodes are that all the resources of nodes are in the idle state. With tasks constantly processed, the idle resources are increasingly consumed and the capacities are reducing. At time t, the load utilization rate of node *i*is denoted $\theta_i(t)$.

$$\theta_i(t) = \frac{S_i(t)}{S_i} \ (6)$$

$S_i(t)$ called used resources denotes the processing capacities that used of node *i* at time *i*. S_i called total resources denotes the total processing capacities of node *i*. At time t the idle resources of node *i* is $ES_i(t) = (1 - \theta_i(t)) \bullet S_i$ .Due to $0 \leq S_i(t) \leq S_i$, then $0 \leq \theta_i(t) \leq 1$ .Through setting two thresholds Θ_1 and Θ_2 determine whether a node is at the balance state or not. The judge rules are as follows:

1) When $\theta_i(t) < \Theta_1$, node *i* is at idle state, which declares that node *i* can deal with its tasks by itself at time t. At the same time, it can as a task receiver to assist other center nodes to complete tasks.
2) When $\Theta_1 < \theta_i(t) < \Theta_2$, node *i* is at the balance state. Not only can it as a task distributer, but also a task receiver. When a node is at the balance state, it declares that at time t node *i* can deal with its present tasks. But its state has the tendency to be the overload state. Therefore, at the time the node is at a semi-closed state, no longer receiving task request from other nodes.
3) When $\theta_i(t) > \Theta_2$, node *i* is at overload state. At the time, the performance of node is declining, which will influence the execution schedule of tasks. Therefore, it needs other nodes to assist it to complete tasks. The system will distribute tasks of the node to appropriate nodes around until the node is at balance state.

3.2.2. Decision Parameters of Task Co-allocation

Decision parameters of task co-allocation are main influence factors on task allocation. The selection of decision parameters is the precondition of correct task allocation. If the parameters are inappropriate, they will not be able to accurately describe load conditions of each node in the network and can't be for the right task assignment in time. That is it can't ease high load condition of nodes, which will influence the regular work of nodes.

Task allocation decision is influenced by many factors which include external factor, intrinsic factor and reinforcing factor. Detailed analysis is as follows.

1) External factor

Distance d: distance is the parameter that denotes the position of nodes in the network. The distance between overload nodes and target nodesaffects the information transfer time directl y. On the case of other parameters are consistent, the closer distance, the more task allocation. The factor is similar to the distance in IV-Vicsek model.

2) Intrinsic factor

Free resources ES: the difference on performance of nodes causes the difference of tasks th ey can deal with. Free resources affect tasks allocation directly. On the case of other paramete rs are consistent, the more free resources, the more task allocation. The factor is similar to the volume of individual in IV-Vicsek model.

3) Reinforcing factor

Service credibility C: security in the process of task allocation is very important. In order t o enhance the security of task allocation and avoid distributing tasks to malicious nodes or no des with lower credibility, the paper used service credibility to measure the credibility of node s in the process of task allocation, which is convenient to exclude malicious nodes and distrib ute tasks to the nodes with higher credibility.

Service credibility denoted C is used to reflectthe completion of tasks within schedule time . The higher credibility, the better services provide and the greater chance for next task allocat ion.

When node *i* distribute tasks to node *j*, the service within schedule time can be divided into completed and uncompleted that denoted CcompleteandCuncomplete. Assume that the times of communication between node*i* and node *j* is n and the number of Ccomplete, Cuncomplete is n_1, n2, then $n=n_1+n_2$. C_{ij} denotes the credibility of node *i* to node *j*.

$$C_{ij} = \lambda \frac{n_1}{n} - \theta \frac{n_2}{n} \quad (7)$$

λ and θ are weight parameters. The bigger value of n_1, the higher credibility. In contrast, the smaller value of n_2, the lower credibility.

In order to avoid evaluation one-sidedness and enhance evaluationprecision to node *j*, the paper considered evaluation from other nodes.

$$C_j = \frac{1}{N} \sum_{k \in D(i)} C_{kj} \quad (8)$$

In formula (8), N is the number of nodes, D(i) is neighborhood range of node *i*.

3.2.3. Task Co-allocation Model

1) Decision formula

A network consists of N subsystems. Each subsystem has a center processing node. S=<N, P, θ >,N= （$n_1,n_2,n_3,\ldots,n_n$） , $n_i \in N$ is processing node of subsystem *i*.

$P=\{\alpha,\beta,\gamma\}$ is a set of influence factors. $\theta=\{\theta_1,\theta_2,\theta_3,...,\theta_n\}$, $\theta_i\in\theta$ is load utilization rate of node *i*. The decision formula is as follows.

$$\theta_i(t+1)-\theta_i(t)=\sum_{j\in D_i(t)}a_{ij}(\theta_j(t)-\theta_i(t)) \quad (9)$$

Node *i* adjusts its load utilization rate through weighted average of difference between other nodes'load utilization rate within the scope of neighborhood and its load utilization rate. $D_i(t)$ denotes a set of nodes within the scope of neighborhood of node *i* at time t, and $D_i(t)=\{D1_i(t),D2_i(t)\}$. a_{ij} denotes comprehensive weight .

2) Division of communication domain $D_i(t)$

When a node needs to distribute tasks, it will preferentially select idle nodes around to complete task allocation. If a nodearound cannot meet need of tasks, then it needs to appropriately extend choose range. Therefore, the paper divided communication domain into two parts depending on the distance to center nodes. The two communication domains are priority allocation area and subprime allocation area. The figure of division of communication domain is shown in Figure 2.

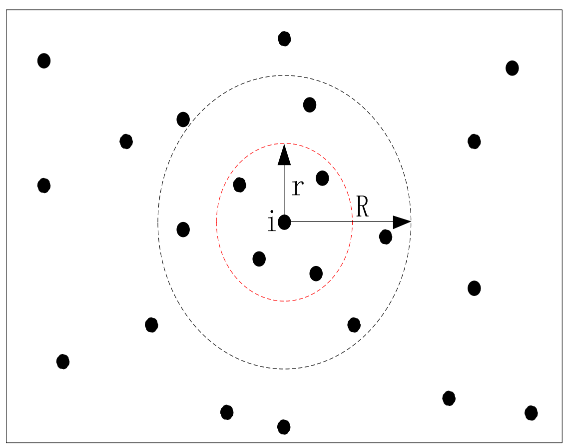

Figure 2. The Figure of Division of Communication Domain

The priority allocation area denoted $D1_i(t)$ is the area of centered on node *i* and the radius is r. The area denoted $D2_i(t)$ is the area of centered on node *i* and the radius is R. The subprime allocation area is the area of r to R, which is denoted $m_i(t)=N_i(t)-n_i(t)$. When a node needs to distribute tasks, it will select target nodes from priority allocation area firstly.

3) Comprehensive weight

Waxman model can be the model in target selecting when a node needs to distribute tasks. But Waxman model only considers the factor of distance [11]. The selection of target nodes needs to consider many factors, such as performance of nodes andmobility,particularly the security of nodes. Therefore, the paper determined the comprehensive weight a_{ij} through combining impact factors of allocation with Waxman model.

$$a_{ij} = \frac{\alpha \bullet ES_j(t)}{S_i} \exp(\frac{-d(i,j)}{L\beta} - \frac{C_j(t)}{C\gamma}) \quad (10)$$

$ES_j(t)$ is available resources that node *j* provides to node *i* within its capability. $C_j(t)$ is service credibility of node *j* at time t. *C* is greatest credibility, *d(i,j)* is distance between node *i* and node *j*. L is the longest distance within neighborhood. S_i is resources that node *i* has. α, β and γ are impact factor to performance of nodes, distance and service credibility. Their value is within (0, 1).

From formula (11)and (12) we can compute the number of tasks that node*i* needs to distribute and the number of tasks that distributed to target nodes. The formula is as follows.

$$\nabla = [\theta_i(t+1) - \theta_i(t)] \bullet S_i \quad (11)$$

$$\nabla_j = \alpha \bullet ES_j(t) \bullet exp(\frac{-d(i,j)}{L\beta} - \frac{C_j(t)}{C\gamma}) \; (\theta_j(t) - \theta_i(t)) \quad (12)$$

4. The Design of Task Co-allocation based on Model IV-Vicsek

4.1. Table Structure of Node Maintains Information

Communication radius of each node in the network is set to R. In order to make sure the task allocation of the central nodes shows a small world model, this paper preferred to distribute tasks to the nodes that near the central nodes. According to the aforementioned definition of two regions, the paper defined two tables that a central node needs to maintain: one is the neighbor table, which is divided into priority allocation area table and sub-priority allocation area table. Both of tables have a same table structure and mainly to gather information of neighbor nodes for task allocation. The other one is the path table, recording the path of mobile nodes that remove from the scope of central nodes, which is very important to the task feedback. The format is shown in Table 1 and Table 2.

Table 1. Neighbor Table

Node Identifier	Distance	Load Utilization	Neighbor Time	Stability	Service Credibility
ID	DIS	Θ	T	S	C

Table 2. Path Table

Allocating Tasks Node	Task ID Array	Relay Node	Effective Bit
ID	T_array[]	ID	Ti

1) Neighbor table

As for the neighbor table, each node in the network maintains this table. The total item of priority allocation area table and sub-priority allocation area table are equal to the number of neighbors of the central node. After the monitoring Agent collects information of the neighbor nodes, the central node sets management Agent, and returns the results to the election Agent. Then, election Agent modifies this table after analyzing the information. The details of each field in Neighbor table are as follows:

Node Identifier ID: Identification number of the neighbor nodes, a unique ID in the network, representing a node.

Distance DIS: Distance from a neighbor node to the central node, a parameter of task allocation.

Load Utilization θ: The workload condition of neighbor nodes， , a parameter of task allocation.

Neighbor Time T: Residence time of a node stay in neighborhood of the central node. When monitoring Agent founds a new node joins in the neighborhood, it starts timing.

Stability S: Stability of neighbor nodes respect to the center node, which is determined by the total time online and neighbor time T. The online time is maintained by each node itself.

Service Credibility C: Service Credibility is standard which can judge the reliability of task execution in neighbor nodes, is an important parameter affects task allocation.

2) Path Table

Path table exists in the neighbor nodes which are distributed tasks, is primarily used to find the path to return task results when neighbor nodes removed out the communicating scope of the central nodes. The details of each field in Path table are as follows:

Allocation Tasks Nodes' ID: Identification of the central node in the allocating task, it exists in the node ID of the neighbor table.

Tasks ID Array T_array[]: A node may be allocated to multiple tasks by a same central node, and maybe receive tasks from different central nodes as well. When receiving a task, the corresponding information is filled in the ID and T_array[].

Relay Nodes ID: Relay nodesare marked node whenneighbor nodes removed out the communicating scope of the central nodes. According to these markers, neighbor nodes will send back the results.

Effective Bit Ti: Ti is used to identifythe relay whether it is effective or not. When a node receives resistor Agent filling in the relay node, Ti is set to the default value of 0, which means invalid. When a node is determined to leave the communication scope of the central node, this bit is set to 1, which means effective. ID in this table is relay node that assigns task.

3) Mobile Agent

Definition of mobile Agent still not have a unified standard, one of the definition of a mobile Agent is: a special program interacts with other Agents, in which a machine can migrate to another machine through the network, and continue to run.

a) Management Agent

Management Agent is a static Agent, whose function can be divided into three parts: firstly, judging the central node whether is overload; then creating election Agent, monitoring Agent and register Agent; finally managing the three Agents. When the management Agent finds the central node is overload, it will inform the election Agentto start the task allocation method on the basisof the neighbor table. Tasks are allocated by Management Agent.

b) Monitoring Agent

Monitoring Agent is a dynamic Agent, which can independently move to anywhere. When a new node joins in the communication range, the main function of monitoring Agent is gathering node's ID, IP address, workload and the relative stability etc. Monitoring Agent is working as long as it staying in the neighborhood of central node and finishing with the node leave. Meanwhile, monitoring Agent collects information every other life cycle. Due to Monitoring Agent is independent of the management Agent, which is not triggered by the management Agent. Therefore, monitoring Agent starts gathering information when a new node joins in or spontaneously starts every other life cycle.

c) Election Agent

Election Agent is a static Agent, which stops working as long as the node disappeared. The main function of monitoring Agent is to analysis data that monitoring Agent gathered, and maintains the neighbor table in the basis of the results. After management Agent triggers election Agent, corresponding task assignment process starts running in the task decision simulator.

d) Register Agent

Register Agent is dynamic Agent that can move independently. When monitoring Agent monitors an allocated tasks node will leave the communication range of center node, it will select a relay node which is within the communication range of center node, steady and nearest to the node that will leave. System sends register Agent with relay agent ID to the node that will leave. The node maintains route table after receiving the information of register Agent. After the node out the communication range of center node, setting significance bit 1 which default value is 0.

4.2. Decision Simulator

Decision simulator is the core of performing task co-allocation. The main function of this part is roughly making the optimal task allocation method in advance by task decision control mechanism according to the collected information of neighborhood nodes, which make task allocation successfully one time. This way can greatly reduced communication lost cased by selecting target nodes in the process of task allocation and improve the efficiency of co-allocation method of task execution. The decision simulator includes calculator and monitor. The core of calculator is decision control formula. Monitor is used to observe changes of load utilization rate in decision control formula. When load utilization rate is than Θ_1 or Θ_2, it needs to adjust until within [Θ_1, Θ_2). The process of task allocation is shown in Figure 4.

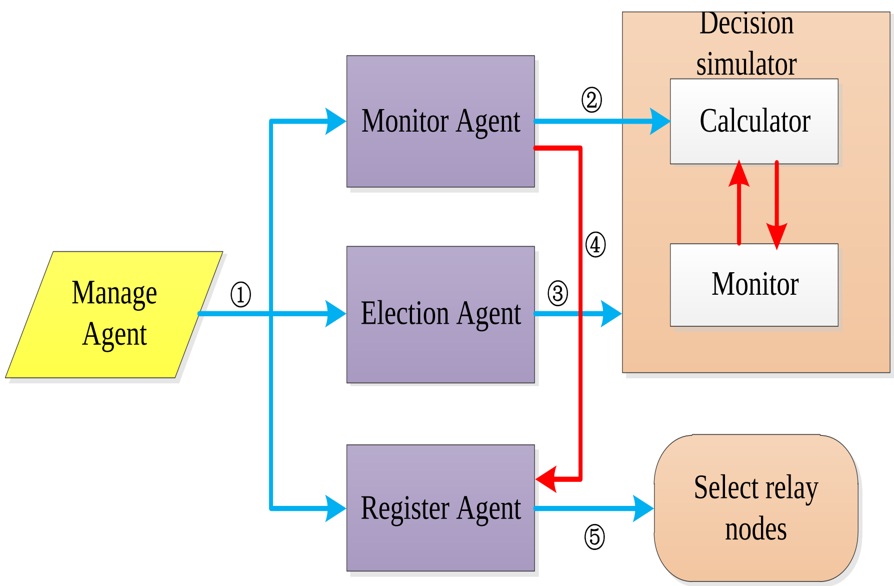

Figure 4. The Process of Task Allocation

Creation: When management Agent detects load utilization rate is beyond the prescribed threshold, it will create monitoring Agent, election Agent and register Agent.

Information transmission: Monitoring Agent sends collected information to calculator.

Start: When load utilization rate is overload, election Agent is triggered by Management Agent and starting decision simulator to adjust task allocation.

Movement: When monitoring Agent detects movement of communication nodes, it will notice register Agent.

Election: Election Agent selects appreciate relay nodes for the mobile nodes in order to ensure accessibility of mobile communications.

4.3. The Execution Mechanism of Task Co-allocation

In this paper, we divided task co-allocation into two phases according to the division of communication range and changes of load utilization rate.

In the first phase, task allocation is executed in $D1_i(t)$. When management Agent detects load utilization rate is not at a state of balance, it will notice election Agent to trigger task allocation. Election Agent will make appreciate task allocation decision according to the information of priority allocation area andformula (9).

In the second phase, task allocation is executed in $m_i(t)$. Manage Agent through changes of load utilization rate determining whether executing the second phase or not.

1) $\theta_i(t+1) \geq \Theta_2$

If load utilization rate of node *i* is still than Θ_2 after computation, which declares that the nodes in $D1_i(t)$ of node*i* have not enough resources to assist node *i* to deal with overload tasks. At the time, node*i* needs to execute task allocation in $m_i(t)$.

2) $\Theta_1 \leq \theta_i(t+1) < \Theta_2$

If load utilization rate of node*i* is between Θ_1 and Θ_2, which declares that node *i* is at the state of balance and can execute task allocation according to result of computation.

The adjustment process is shown is Figure 5.

1)Management Agent detects node load utilization rate.

2)When the load utilization rate is out a certain threshold range, starting the decision level and calculating the comprehensive weight.

3)First, executing the decision control formula in $D1_i(t)$. If load utilization rate of all nodes is not out threshold, executing step 4. Else, adjusting the parameters and extending communicationrange to $m_i(t)$.

4)Distributing tasks to appreciate nodes according to allocation scheme made by step 3.

5)End of allocation.

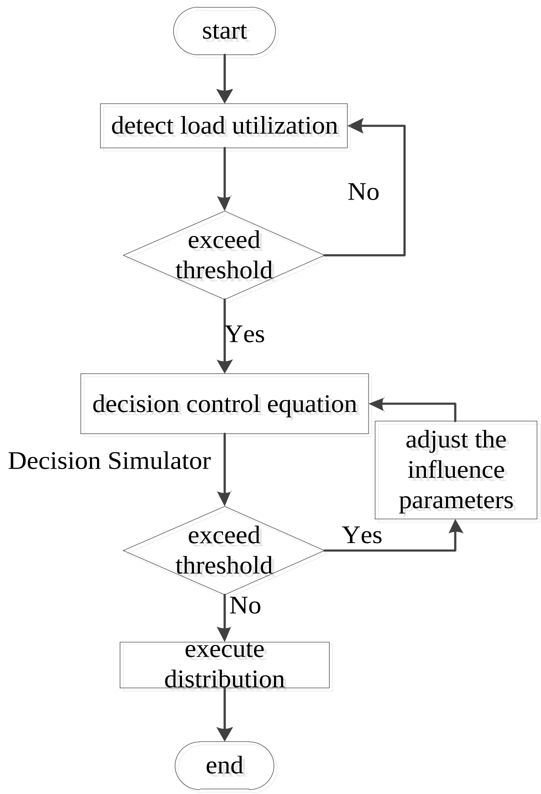

Figure 5. The Process of Task Co-allocation

4.4. Mobility Processing Mechanism

The success of task allocation is decided by whether the result of task allocation can be returned to the node that distributes tasks. However, due to the highly dynamic nature of MP2P network, mobility of nodes becomes an important factor of the task allocation. Using return blindly or flood will greatly increases the cost of communication and may also lead to the leakage of private information which influences communication security. Therefore, in order to solve the above problem, this paper proposed a binary routing method based on relay Agent that uses register Agent to find suitable relay node and then to complete return.

1) Division of movement region

In order to avoid waste on time and resources caused by choosing improper nodes to forward, it needs to choose proper relay node to return. This paper divided several regions that is shown in Figure 6.

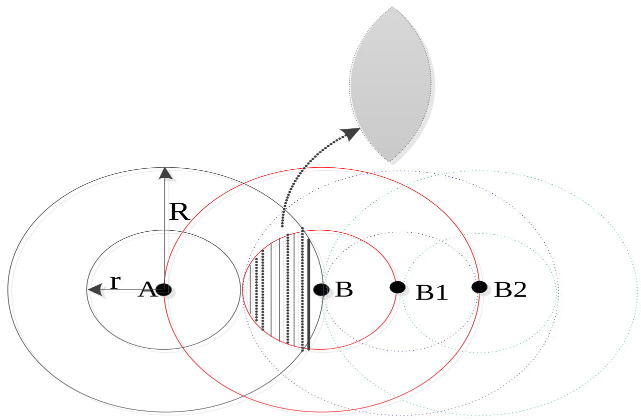

Figure 6. The Selection of Relay Agent

The first region is the region between B and B1.The second region is the region between B1 and B2.The third region is the region out of B2.Monitoring Agent monitors the position of nodes and selects appreciate relay agent for them in time. Monitoring Agent can monitor the condition of the first region and the second region.

2) Selection of relay Agent

When monitoring Agent monitors that node B will out the communication of node A, management Agent of node A creates a register Agent to select relay agent for node B. If a node moves to the first region, the range of relay agent selection is the dash area in Figure 6. The relay agent must have higher stability than node A and nearer to node B. Therefore, we used formula (13) to select relay node.

$$CS = \alpha \bullet S_A + \beta \bullet DIS_A \quad (13)$$

In formula (13), S_A is stability; DIS_A is distance to node A. α and β are influence factors of stability and distance. In this paper, $\alpha > \beta$ that is stability is more important than distance.

Register Agent selects the node with max CS as relay agent for node B. Node B fills route table after received register Agent. When node B is out range communication of node A, the route table takes effect.

When a node moves to the second region, the selection range of relay node is the grey part in Figure 6. When a node moves to the third region, the communication between them becomes complex. For example, this paper used node A and node B2 to illustrate task return. Assume that the route table of node B2 is shown in Figure 7.

□□□□□□ ID	□□□□□□ T_array[]	□□□□ ID	□□□ F
A	21450	W	1

Figure 7. Route Table of Node B2

If node B2 is out of the communication range of node A, node B2 needs to broadcast in communication area to find which node has record of node A when node B2 return result to node A. If node W responses node B2, B2 returns result to node A via node W.

5. System Simulation and Performance Evaluation

This paper made simulation analysis from the average execution time delayand the number of completed tasks and compared with DFPSO and Random.

In simulation experiment, nodes are distributed in the range of 1200m*800m randomly and using Random Waypoint Model (RWM) to move at a speed of 0~10m/s. The communication distance is 250m, and the foundation network uses ieee802.11 protocol, the transport layer uses UDP protocol. The simulation time is 1200s, threshold of load utilization rate Θ_2 and Θ_1 are set 80% and 40%. In order to make simulation convenience, the paper only considered the influence of performance, distance and service credibility. The values of their factors α , β and γ are set 0.6,0.2 and 0.2.

5.1. Load Utilization Rate

In the simulation experiment, we set 100 nodes and 50 times iteration. The changes of load utilization rate are shown in Figure 7. Picture a, b, c and d denote initial state, 1 time iteration, 2 times iteration and 50 times iteration respectively.

The load utilization rate of nodes is different in initial state. From Figure 7 we can know, load utilization rate is to the middle gradually after several times iteration. The load utilization rate of nodes reached 50% basically after 50 times iteration. The system is at the balance state.

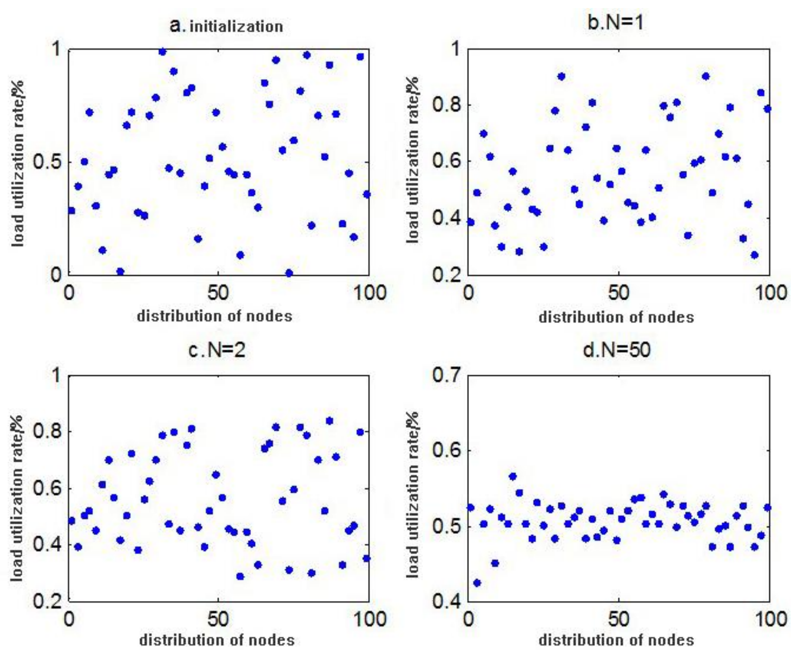

Figure 7. Changes of Load Utilization Rate of Nodes

5.2. The Average Execution Time Delay

In this paper, we compared the method of task co-allocation based on IV-Vicsek model (HCCTAM) with DFPSO on the average execution time delay. The comparison result is shown in Figure 8, Figure 9 and Figure 10.

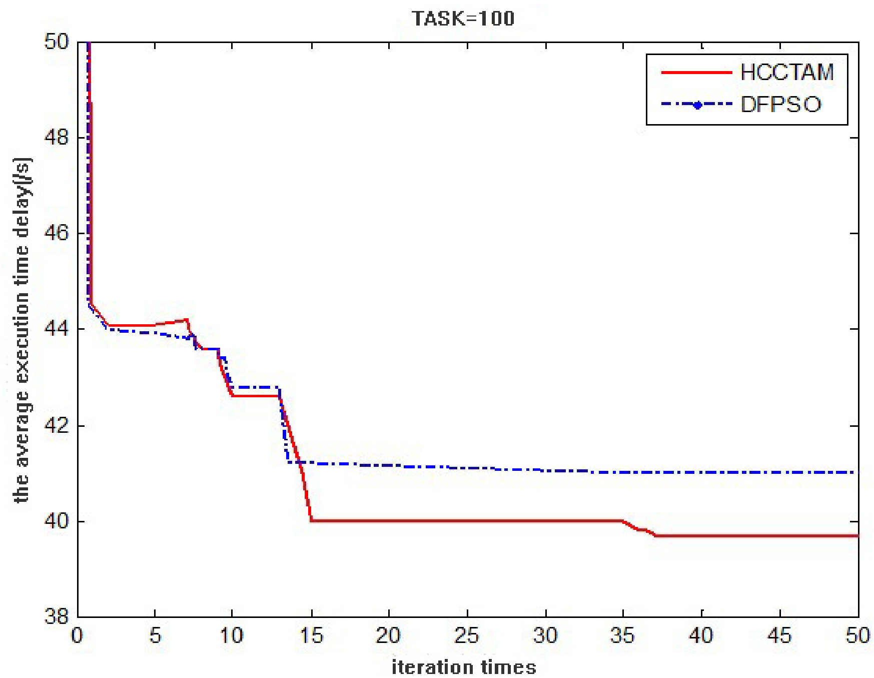

Figure 8. The Average Execution Time Delay when Tasks=100

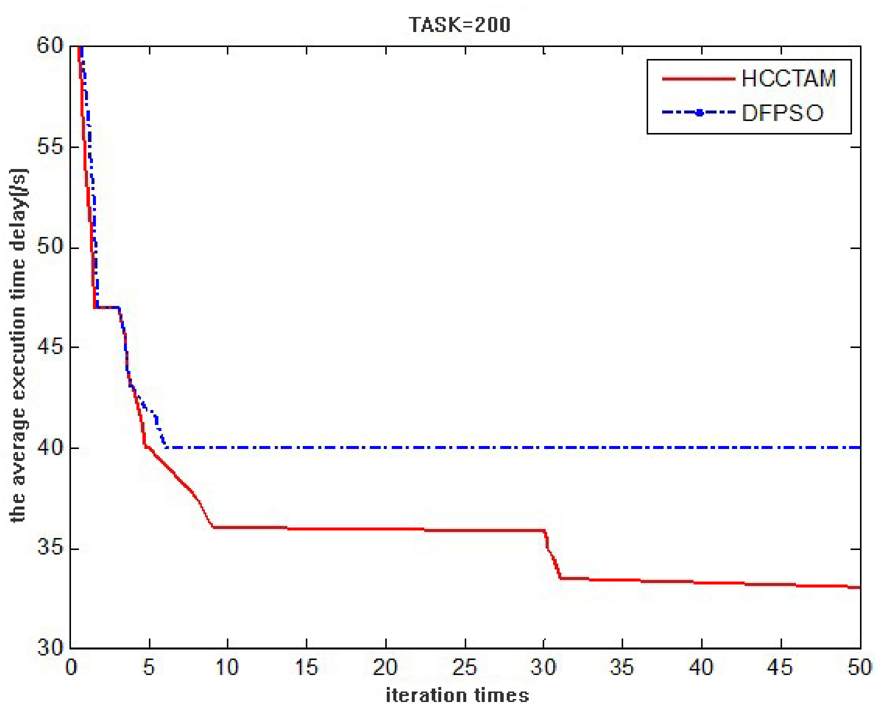

Figure 9. The Average Execution Time Delay when Tasks=200

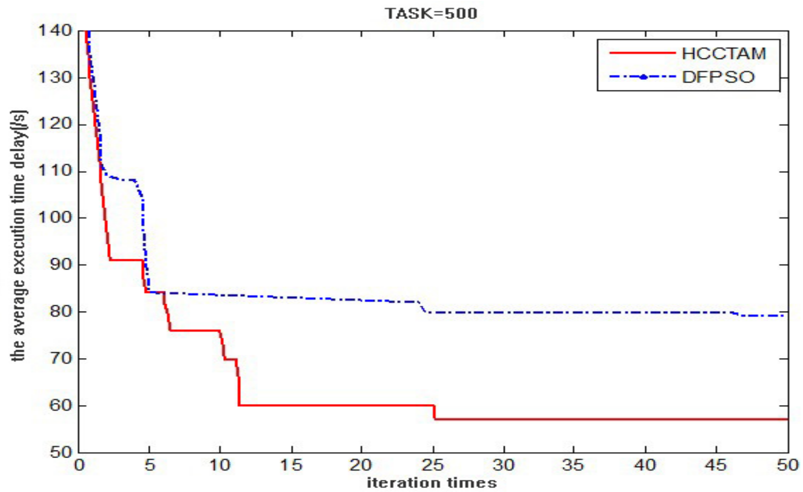

Figure 10. The Average Execution Time Delay when Tasks=500

From the three figures, we concluded that HCCTAM is less than DFPSO on average execution time delay. And the more tasks, the larger difference between the two methods. Therefore, the proposed method is effective.

5.3. The Number of Completed Tasks

At the same time interval range, we compared HCCTAM with DFPSO and Random on the number of completed tasks. The result is shown is Figure 11.From Figure 11, we concluded that the number of completed tasks of HCCTAM is more than other two methods.

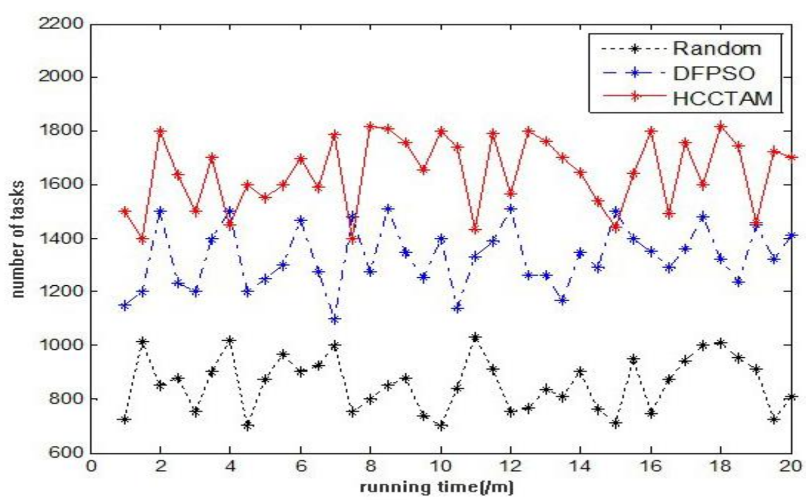

Figure 11. The Number of Completed Tasks of Three Methods

6. Conclusion

In view of the existing large-scale distributed mobile network cannot give full play to node processing capabilitywhich leads to network load imbalance, this paper combined MP2P and swarm intelligence proposed a method of task co-allocation.Firstly, in view of the Vicsek model cannot match task co-allocation, this paper analyzed the Vicsek model and its improved model, proposed the IV-Vicsek model;Secondly, on the basis of this model, through the analysis of the main affecting factors of task co-allocation and the relationship between them we built a task co-allocation model;Thirdly, we designed the execution process of task co-allocation methods in detail; Finally, we proposed the binary routing method based on relay agent to solve the problem of communication terminal caused by nodes mobility in task allocation process.Through simulation experiment and the analysis of data, verifying the proposed method not only greatly improved the efficiency of the task execution of MP2P network, but also enhanced the robustness of the network.

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