Research of Seamless Migration Mechanism on Wisdom Space Software Support Platform

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Abstract—High mobility of computing entity and user in the physical space is an important feature of smart home environment. In order to provide transparent digital services for users "anytime, anywhere", seamless migration as the core issue must be addressed, that is, with the user's mobile, accompanied computing tasks must be ensure sustained implementation on one hand, on the other hand calculate task can move without interference. In this paper, we focus on the smart home environment, which is parametric-based model, with automatic adaptation mechanism for high availability and scalability of smart home software support platform. The software support platform which use the IPv6 protocol to build home information network, can support users transparent operation, improve the efficiency of the user, and enhance the user experience, as well as provide a unified public service development platform for system developers to simplify the development of ways and improve development efficiency.

***Keywords-** smart home; software support platform; seamless migration; Multi-Agent Technology; IPv6*

I. INTRODUCTION

As an important application of pervasive computing, in the smart home, in order to achieve “whenever, wherever and transparent access to digital service”, people try to allow the mutual application migrate in the corresponding space, so that people not only can maintain a continuous conversation, but also could be given the space they are familiar with, which has positive effects on improving efficiency and customer satisfaction. The application seamless migration allows people do not care about the distribution of applications and services, but focus on the quality and connotation. Seamless migration is mainly about how to ensure seamless migration of user’s tasks to a new scene will take the initiative to continue to execute, and its functional requirements is mainly embodied in the continuity of the self-adaptability and initiative.

As the forerunner of pervasive computing, CMU and Illinois University have developed the Aura[1] program and Gaia[2] system respectively. Aura separated the composed of application components into supplier and connector by abstracting the user task, and realized the reconfiguration of application through dynamic binding of supplier and connector. However Aura has not stated how to adapt to the heterogeneous supplier and also has not elaborated synchronization among a plurality of tasks.

Gaia required custom profile of applications (Application Customized Description), which was achieved through remote access after switch the computing environment, realizing loading execution state and a continuous execution of application. However, this process requires user intervention, and Gaia focused mobility, synergy and lifecycle management, and many other factors on static collaboration module, which was easy to form the bottleneck.

Stanford University researchers have proposed "computing capsule" [3] which is a new abstraction mechanism and can be used to rebuild the operating system. Computing capsule provided a private, virtualization, machine-independent system resources interface, encapsulated all the state run during a user task, which separated application state with user data, to provide support for application migration. Similarly, Chandra at Stanford University also used a centralized management of collective [4] to support application migration. The core idea is separating application status and user data and storing them in two different cache containers respectively through a cache-based system management mechanism, which facilitate to move the application to new computing device.

The method jointly proposed by Miehael A.Kozuch at Intel Labs in Pittsburgh and M.satyanarayanan at CMU [5] [6], can implement the entire contents of the virtual memory migration from one computer to another computer, enabling users do not have to carry a computing device, and use another computer in the service area freely without carry a computing device. However, the limitation of this approach is that such tasks run on one computer, and user tasks can only be migrated between compatible computers. And that, this method support migration of user tasks in a very simple way, means that, each active service constituting of the user tasks in the machine will be migrated.

In home wisdom space environment, users and wisdom devices have frequent mobile properties [7]. How to provide support seamless application migration for software technology in the wisdom space environment is an urgent but very difficult problem. Its goal is the user's task can be suspended anytime and anywhere without the user any active operations and can continue to perform on different devices in other places [8]. Seamless application migration issues involving core software infrastructure needs in-depth study architecture, service building model, the development environment and software programming mode of the wisdom space software platform. From software perspective, the home wisdom space applications can be viewed as consisted by a set of services and a group of resources. To achieve seamless migration scenario, the user's task must have services and resources related dynamic adaptation mechanisms. Therefore, we research service, resource and dynamic adaptation method of tasks at the aspect of Multi-Agent System operational mechanism in IPv6-based intelligent home network, in order to achieve spontaneous operating and scenes migration of intelligence equipment in heterogeneous environments.

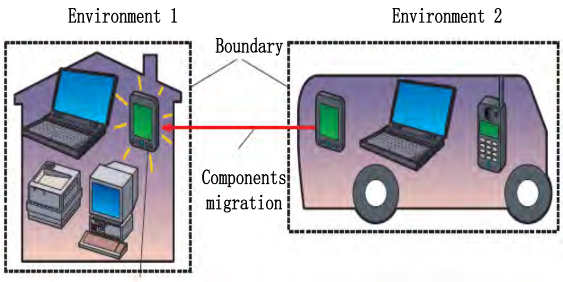

Figure 1. Application of seamless migration

II. BASE FRAMEWORK OF SCENE MIGRATION

We divide software dynamic adaptation mechanism framework from bottom to up into four levels including the device resource layer, the sensing recognition layer, the task layer and functions performed layer, as shown in Fig .2. Unified access interface of each layer is based on the parameters model, which access a unified form for the upper layer, and shield and package differences caused by the lower layer diversity. Unified access interfaces are all implemented by a variety of specific Agent.

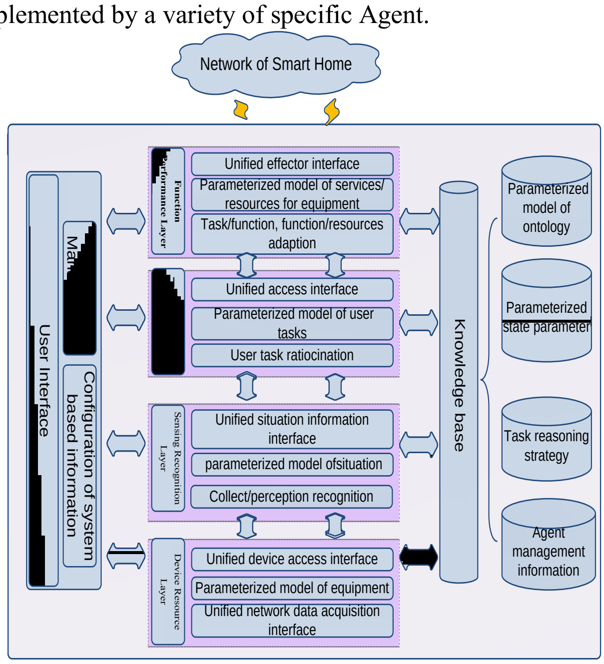

Figure 2. The framework of software dynamic adaptation mechanism implementation

III. RESEARCH OF SEAMLESS MIGRATION OPERATING MECHANISM

Operating mechanism uses Multi-Agent Systems (MAS). Function of the system is completed through coordination operations such as communication and union between Agents, to achieve system optimization. In this system, we use the IPv6 protocol to build home information network, which has the following advantages: (1) sufficient address space; (2) addresses and services automatic configure; (3) safety; (4) mobility support; (5) QoS support.[9] Implementation mechanism of the system is shown in Fig .3. The main function of the system is shown as followed:

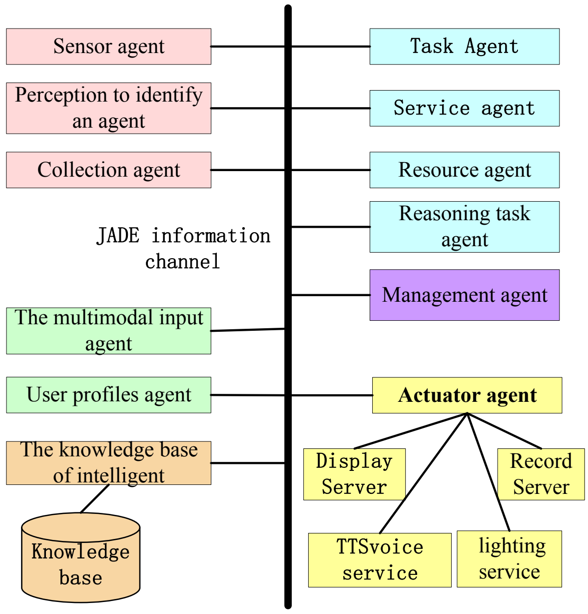

Figure 3. Agent-based dynamic adaptation of operating mechanism

A. *Intention recognition of dynamic data*

Dynamic data collected by the sensor including sound and image data, etc., which must be able to obtain dynamic context information that perceive the reaction of user's intention such as user identity, position and the like [10]. Firstly, for characteristics of large amount of data, high real-time of dynamic data acquisition, we uses a technology based on NIST Smart Flow, combines with distributed middleware device parametric model of flow data resources, to realize distributed processing flow data, meet different intentions needs of the application and the load balancing algorithm for recognition; Secondly, we use video recognition techniques to identify the user's identity and orientation from the stream data. Combining parameters model of the context, we improved IBM CHILIX library to obtain the user's intention as the system dynamic context information parameters and combined context information to generate a unified situational information access interface.

B. *User task ratiocination*

Based on the user's explicit request or contextual information changing, the software platform automatically process semantic-based ratiocination, to infer the tasks user needs to perform [11]. We use CLIPS inference engine based Jess Java language as the underlying reasoning, set RDF (S) / OWL mapping layer, definite the basic facts and the pros-cons chain rule, according to the requirements of the model parameters context, to generate new facts and reasoning user tasks automatically based on user requests or situational information changing.

C. Task / function adaptation

In the adaptation phase, user's tasks are resolved into subtasks and each sub-task function can be settled by Agent system. We use Agent Union to complete the adaptation of tasks and functions. Essentially, the formation and evolution issue of Agent optimal structure can be attributed to combinatorial optimization problems. As Genetic algorithm and Ant colony algorithm is NP good algorithm based on solving combinatorial optimization problems, we research a novel hybrid ant colony genetic algorithm in allusion to the advantages and disadvantages for both. According to ant colony algorithm can appropriate remedy genetic algorithms not enough using feedback information, the combination can improve accuracy and genetic algorithms can suitable remedy ant colony algorithm for solving the problem of slow. The algorithm has higher effect in time and precision of optimal solution problem for solving alliance

The system ordered the tasks in T according to the degree of urgencyU_t at first, and then solved the problem in proper order. When the algorithm obtained the optimal Agent Union of missiont_j, began to solve the optimal union of next taskt_(j+1). The pheromone between Agents no longer is the initial valueτ_0, but residual pheromone τ_ij (t)at the end of last solution procedure. As valuable experience knowledge, it will effectively guide the process behind in ant colony algorithm, reducing search time and computation.

Rules of setting the initial pheromone distribution are as follows:

$$\tau ij(0) = \begin{cases} \tau_{min} + \tau_g \text{, when } x_i = 1, x_j = 1, 1 \le i, j \le n \text{ and } i \ne j \\ \tau_{min}, \text{ else} \end{cases} \quad (1)$$

Among, τ_{min} is the pheromone minimum of edge between Agents, which is pre-establish. τ_g is the pheromone according to the results of the conversion of genetic algorithms. Namely: in the solution obtained through genetic algorithm $X = (x_1, x_2, \dots, x_n)$, if $x_i = 1$, $x_j = 1$ then pheromone of edge (i, j) is $\tau_{min} + \tau_g$.

The rule of Ant k in node i to select the next node j is:

$$p_{ij}^k = \begin{cases} \frac{[\tau_{1j}(t)+\tau_{2j}(t)+\cdots+\tau_{ij}(t)]^\alpha}{\sum_{u \in J_k}[\tau_{1u}(t)+\tau_{2u}(t)+\cdots+\tau_{iu}(t)]^\alpha} * \frac{(d_{1u}+d_{2u}+\cdots+d_{iu})^\beta}{(d_{1j}+d_{2j}+\cdots+d_{ij})}, j \in J_k \\ 0, \quad else \end{cases} \quad (2)$$

$$\tau_{ij}(t+1) = \rho.\tau_{ij}(t) + \lambda\Delta\tau_{ij} \quad (3)$$

Among, （1-ρ) is Volatile factor, λ is Coefficient of pheromone update. They meet the following formula

$$\rho = 0.9^{1+N}/_{100} \quad (4)$$

$$\lambda = 1.001^N \quad (5)$$

thereto, N is the number of ant colony algorithm cycle.

In order to avoid algorithm premature convergence non-global optimal solution, we limit pheromone concentration for each path between $[\tau_{min}, \tau_{max}]$, values outside this range are forced to τ_{min} or τ_{max}.

$$\tau_{ij}(t+1) = \begin{cases} \tau_{min}, \quad \text{when } \tau_{ij}(t) \le \tau_{min} \\ \tau_{ij}(t), \quad \text{when } \tau_{min} \le \tau_{ij}(t) \le \tau_{max} \\ \tau_{max}, \text{when } \tau_{ij}(t) \ge \tau_{max} \end{cases} \quad (6)$$

We combine genetic algorithm and ant colony algorithm, and make appropriate improvements, in order to obtain high accuracy and fast convergence for solving algorithm.

Algorithm is described as follows

Step 1

Initialize genetic algorithm: randomly generated initial population $P(0)$; $t = 0$.

Step 2

While (t≤ T) do //T is Specified algebraic

{

for i=1 to p do // Fimess Function

Compute the fimess function $f(C_i)$ of each entityCi in current group $P(t)$

for i=1 to p do //selection

According to fimess function $f(C_i)$ of each entity Ci in current group $P(t)$ to generate intermediate group

for i=1 to p do //crossover

Improve uniform operator according to probability Pc in population, new individuals will replace the original self-generated and inserted into the population $P(t)$;

for i=1 to p do // aberrance

Select an individual to variation in probability Pm, new individuals will replace the original self-generated and inserted into the population $P(t)$;

for i=1 to p do

$P(t+1) = P(t)$;

t=t+1;

}

Step 3

e middle optimization solution vector X=P(t ＋ l);

Step4

if (T ≠ ∅) then

Order tasks in T according to The urgent degree of task $U_t, t_1', t_2', \dots, t_n'$. t_1'The most urgent task at present

else

Terminate the entire program

Step5

if (Ball-Agents<B_t) then

Goto Step 13

else

Goto step5

Step6

Initializes the ant colony algorithm:

$t = 0; N = 0;$

for each edge

$$\tau_{ij}(t+1) = \begin{cases} \tau_{min}, \quad \text{when } \tau_{ij}(t) \le \tau_{min} \\ \tau_{ij}(t), \quad \text{when } \tau_{min} \le \tau_{ij}(t) \le \tau_{max} \\ \tau_{max}, \text{when } \tau_{ij}(t) \ge \tau_{max} \end{cases}$$

{

according to middle optimization solution vector X，like formulation (1) Get the initial pheromone $\tau_{ij}(t)$，$\Delta\tau_{ij}(t) = 0$;

}

Step7

Set the current collection Agent which has not been visited：$J_k = \{a_1, a_2, \dots, a_n\}$

Placed m ant to n Agent Randomly

for k=1 to m do

{

Record the Agent where k ant on is a_i, and delete a_i from J_k

Calculate the initial union ability vector B_{C_k};

}

Step 8

for k=1 to m do//routing selection

While ($B_{C_k} \le B_t$)

{

On the basis of formulation (2) choosing next Agent j, and move the ant to Agent j, and delete a_i from J_k , Calculate the initial union ability vector B_{C_k};

}

Step 9

for k=1 to m do// Calculate the optimal coalition according to

$$V(C_k) = P(t_j) - F(C_k) - C(C_k) \quad (7)$$

calculating the value of the first k ants formation of the alliance $V(C_k)$, Update the maximum union and its Allies.

Step 10

If (maximum union ≡maximum union of the previous N cycle)

Then if (g++≤ g_{max}) then g++

else g=g_{max}

Step 11

for k=1 to m do

according to formulation3,4,5,6, update the edge pheromone $\tau_{ij}(t+1)$

Step 12

Set t=t+1

Set NC=NC+1

Set $\Delta\tau_{ij}$=0

Step 13

if (NC < NC_{max}) and (Not for a long time no evolution)

then $J_k = \{a_1, a_2, \dots, a_n\}$,

Goto step 6

else

output maximum union and its Allies Step 14

delete t from T，m=m-1, $\tau_{ij}(0) = \tau_{ij}(t)$

Goto step 5

D. Function / resource adaptation

In the adaptation phase, we use multi-Agent negotiation mechanism to allocate resources to the various service functions, which avoid equipment resources conflict, to ensure service functions implemented successfully. We use multi-issue negotiation based on game theory and learn optimal policy and the opponent preference through interactive negotiation process. It realized equipment favorable allocation of resources among different Agent, and ensured the optimal of overall effectiveness and Pareto optimal of individual effectiveness.

IV. CONCLUSION

Mobility of users and devices has caused changes in the environment and the scene, which may lead to service migration and user tasks demand changes. In order to ensure self-adaptive of intelligent home environment services, in this paper we focus on the smart home environment, which is parametric-based model, with automatic adaptation mechanism for high availability and scalability of smart home software support platform. The software support platform can support users transparent operation, improve the efficiency of the user, and enhance the user experience, as well as provide a unified public service development platform for system developers to simplify the development of ways and improve development efficiency.

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