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Author(s)	峯下, 聡志
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# Formalization of Mobile Agents with Ambient Calculus

Satoshi Mineshita

School of Information Science,  
Japan Advanced Institute of Science and Technology

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## Abstract

## Introduction

Studies on formal semantics of distributed programming languages and its related research topics are getting important these days. Formal semantics is necessary in order to truly understand the nature of a programming language and the behavior of programs written in the language. Therefore, the exact description of semantics in distributed programming languages is urgent, and it is connected to the development of distributed softwares by this exact description.

The purpose of this study is to give it formal models, specifications of the various motions of realistic mobile agents. In this study, specially, it thinks about the various motions of mobile agents when physically cutting of the communication happened, and two formalization of the fault tolerance and the disconnected operation are decided to be done.

The disconnected operation handles the process of keeping the work, while the result is always returned in the middle point. The fault tolerance handles the result which the emergency process operates, when the communication is not taken in point of time in which the countdown ended.

## Mobile Agent

Mobile agents are programs that move and execute on the network with data, and agents that does the agency of processing of the addressee in remote process. There are many

things that mobility, autonomy, communication, parallelism, security is demanded in the mobile agent, and when they are included, it thinks how disconnected operation and fault tolerance are included. Actually, each mobile agent language is developed a various view and have the different style. But, the thing which had the recovery function when a device trouble and a trouble occurred is still difficult, and it is a future research subject.

Calculus that a mobile agent is expressed must have its expression which has characteristics being looked for in the above. As for communication, CCS(Calculus of Communicating Systems) which are formal models of the parallel computing exists, and PI-calculus that the movement of processes is represented as the movement of a channels that refer to processes exists. Ambient Calculus which was underlain concepts and techniques of  $\pi$ -calculus makes a movement occur on ambient and all which is the bounded placed which a calculation occurs in, and it thought that its technique was suitable for expressing a mobile agent, and we did research in this cause.

## Formal Semantics

How to describe the semantic of program languages strictly by the mathematical or formal logical system is the formal semantics of programming languages, by this, the standardization of program languages, the verification of correctness, the exact description of specifications, the automatic generation of processors can be done.

In this study, we was used operational semantics that express the semantic of programming languages by giving it the abstract machine which has the structure that the effect of program languages can be judged.

## Ambient Calculus

Ambient Calculus to use by this study has its expression which can model firewall access, numerals, Turing machine by using the concept of ambient and the peculiar action that is entering, exiting, opening up an ambient.

Furthermore, by adding the concept of the interprocess communication, it makes encoding of  $\pi$ -calculus possible, and it is shown that an expression is high.

## Representation of Mobile Agents

In this study, we define a countdown, working impossibility condition and by using these, the semantic of two condition is decided to be given to it.

One of those is disconnected operation of mobile agents. In this study, it is thinking about the process that the work is continued with returning always a result on the way. As an example, The case that it is indicated how much work a mobile agent during the work finishes at present in the transmitting cause is presumed.

Route confirmation between ambients, a base for the data transmission , a base for the data delivery one by one, transmitting data are defined, by using these, disconnected

operation that when it can communicate the place of sending of the transmitting data, sending of data is done and when it cannot communicate, before sending data, it is made work impossibility condition, and made the condition that it waits for the next sending data is defined.

Another of those is fault tolerance in physically cutting in mobile agents. When physically cutting happens, a countdown is done because the judgment of permanent cutting or temporary cutting is difficult, and when a countdown was finished, if communication cannot be taken, the process for the emergency starts and fault tolerance is done.

A base for the round agent, a round agent are defined, and it is defined that fault tolerance is done when this round agent is made to work continuously and round agent doesn't come back to the base.

## **Confirmation of motions**

Motion of the motion impossibility condition and the above two definitions are confirmed, and it ascertains that a motion as the specifications is done.

Reductions are done, and verifications are done by confirming a change in that condition.

## **Conclusion**

The motion of the actual mobile agent could be expressed by Ambient Calculus which had only primitive element.

As that result, the base to examine the behavior of the distributed calculation mathematically could be made, and moreover the Ambient Calculus' own expression could be confirmed.