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New analysis on mobile agents based network routing

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Abstract

This paper focuses on behavior analysis on mobile agents used in network routing. We describe a general agent-based routing model and classify it into two cases based on the reaction of mobile agents to a system failure, namely mobile agents with weak reaction capability (MWRC) and mobile agents with strong reaction capability (MSRC). For each case, we analyze the probability of success (the probability that an agent can find the destination) and the population distribution (the number of mobile agents) of mobile agents. The probability of success serves as an important measure for monitoring network performance, and the analysis of population distribution provides a useful tool for reducing the computational resource consumption. Our analysis reveals theoretical insights into the statistical behaviors of mobile agents and provides useful tools for effectively managing mobile agents in large networks.

Keywords: Mobile agents; Routing; Probability of success; Population distribution

1. Introduction

Mobile agent, a relatively new paradigm for network software development, has become an accessible technology in recent years. The potential benefits of this technology, including the reduction of network bandwidth consumption and latency, have drawn a great deal of attention in both academia and industry [3,11,19,20]. A mobile agent is a program that acts on behalf of a user to perform intelligent decision-making tasks. It is capable of migrating autonomously from node to node in an information network.

In recent years, many intelligent mobile agent-based network management techniques have been proposed and implemented [1,6,10,14]. When a mobile agent is encapsulated with a task, it can be dispatched to a remote node. Once the agent has completed its tasks, the summary report for its trip is sent back to the source node. Since there are very few communications between the agent and the source node during the process of searching, the network traffic generated by mobile agents is very light. So, mobile agent is an effective way for improving network performance.

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Network routing is an important issue for network performance. Advanced research in mobile agent has brought in some new methods for network routing [5,15]. Ant routing algorithm is a recently proposed routing algorithm for use in large dynamic networks [7,13,17,21]. The idea is similar to the shortest path searching process of ants. For an agent-based network, agents can be generated from every node in the network, and each node in the network provides mobile agents an execution environment. A node that generates mobile agents is called the server of these agents. Once a request for sending a packet is received from a server, the server will generate a number of mobile agents. These agents will then move out from the server to search for the destination. Once a mobile agent finds the destination, the information will be sent back to the server along the same path. When all (or some of) the mobile agents come back, the server will determine the optimal path and send the packet to the destination along the optimal path. At the same time, the server will update its routing table.

Since mobile agents will be generated frequently in the network, there will be many agents running in the network. On one hand, if there are too many mobile agents running in the network, they will consume too much computational resource, which will affect the network performance due to the limited network resource and ultimately block the entire network; on the other hand, if the number of generated agents per request is too small, we cannot get a high probability of success. Therefore, analysis on mobile agents is necessary and important for network management. Unfortunately, few works have been done on this aspect.

In [18], an ant routing model was proposed and the number of mobile agents was estimated under the assumption that nodes in the network will not fail. Thus, it can be viewed as a special case of the model in this paper. In [16], a smaller upper bound of the number of mobile agents was provided based on the same model in [18], and for the first time the probability of success was considered. In this paper, we describe a general mobile agent-based routing model and classify it into two cases based on the reaction capability of mobile agents to a system failure. For each case, we analyze both the probability of success and the population distribution of mobile agents. Our contributions are summarized as follows:

- A general agent-based routing model is described and is classified into two cases based on the reaction of mobile agents to a system failure: MWRC and MSRC.
- The probability of success is analyzed for each case, which serves as an important measure for monitoring network performance.
- Analysis on population distribution of mobile agents is presented for both cases, providing a useful tool to reduce the computational resource consumption by adjusting the number of agents to be generated at individual nodes and the life span of these mobile agents.

In any mobile agent-based routing models, mobile agents must be generated and dispatched to the network frequently. Although a large number of agents generated per request would bring a high success probability, an excessive number of agents will consume too much computational resources due to per-agent overhead. Our results provide a guideline for choosing a suitable propagating rate to benefit both the probability of success and the network performance (illustrated by the population distribution). The results are extremely useful when the computational power of the host servers is limited, which is unable to handle large amount of processing requests and/or the network channel capacity is limited for large volume of mobile agents propagating in the network.

The rest of this paper is organized as follows: Section 2 discusses related work; Section 3 describes our model; Section 4 introduces the notations used in this paper and presents the analytical results for mobile agents, including the probability of success and the population of agents; Section 5 concludes the paper.

2. Related work

A mobile agent is an autonomous object that possesses the ability for migrating autonomously from node to node in a computer network. Usually, the main task of a mobile agent is determined by specified applications of users, which can range from E-shopping and distributed computation to real-time device control. In recent years, a number of research institutions and industrial entities have been engaged in the development of elaborating supporting systems for this technology [11,23]. In [11], several merits for