DEPARTAMENTO DE CIÊNCIA DA COMPUTAÇÃO

Relatório Técnico

RT-MAC-2001-14

A CONNECTIONLESS PROTOCOL FOR MOBILE AGENTS

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A connectionless protocol for mobile agents

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Abstract

This article describes RDP-R, a client-server protocol which implements reliable delivery of messages to mobile hosts. This protocol is a modification of the RDP (Result Delivery Protocol) [1] that is able to perform even on the event of failure of the fixed communication stations that serve as intermediates between the Mobile Hosts and the Servers.

1 Introduction

In the last two years we at the Sidam project [2] (Distributed Information Systems for Mobile Agents) at the University of São Paulo have been studying the main issues involved in the implementation of distributed information services to be accessed by mobile agents. We are currently trying to model an on-line system that provides traffic information for mobile clients in a big city like São Paulo, Brazil. In particular, we have been trying to develop request delivery protocols for the reliable communication between mobile agents and servers. A first protocol, RDP (Result Delivery Protocol) has been proposed [1]. However, RDP makes some assumptions about the robustness of the communication network that can limit its application. This paper presents a new protocol that imposes less stringent requirements, being able to work even on failure of the communication stations. This protocol is part of an effort to develop a set of protocols that will adapt to different conditions, ensuring the best mobile agent communication according to the characteristics of the applications and systems.

2 System model

In our system we are modeling a mobile client trying to obtain information from a central database. This client sends a request that is forwarded to the server, which eventually sends a reply. The model is non-synchronous, the client is not blocked, being able to send new requests while it is waiting. We have 3 types of machines: Servers, Message Service Stations (Mss), and the Mobile Hosts (Mh). The servers store the information to be retrieved for each request. The mobile hosts are the client machines, where the requests for information originate. The Mobile hosts do not communicate directly with the servers.

Instead, a network of Message Service Stations are used to intermediate the communication. Each Mss covers specific geographic region. Mobile Hosts always communicate through an Mss that covers its current geographic region.

Message Service Stations may communicate or not. Mss's communicate with the servers through a reliable network.

The main assumptions of the model are the following:

- at any time a Mh is associated with only one Mss
- an Mh is able recognize retransmissions from the same reply
- if an Mh is active, it must acknowledge all messages received from its current Mss. An Mh is considered inactive during the migration from an Mss to another and must not send any acknowledgments during this period.
- an Mh only leaves the system after aknowledging all messages received from its Mss.

3 Robust Result Delivery Protocol

The Robust Result Delivery Protocol (RDP-R) is based on the notions of *request proxy*, *memento* and *garbage collection*. A *request proxy*[1] is a process running in a Mss that represents the Mh and its pending requests. A *memento* is a piece of data containing the pending request history for a Mh. *Garbage collection* is the procedure to locate unused resources of the system, freeing them for future use.

A *request proxy* is created each time an Mh that has no request pending issues a request. The request proxy is a "representative" of the Mh in the Mss. When a first request is sent from a Mh to a Mss, a proxy is created in the Mss, this proxy is a process that contains the description of all pending Mh requests, and an identification of its corresponding Mh. Each Mh stores within itself a *memento* of the pending requests. A memento can be seen as a "black box" containing all information needed to reconstruct a request proxy, if needed. This memento can be created locally by the Mh or, alternatively, can be sent back by the Mss when each request is made. The second alternative increases communication costs, but allows the proxy to contain much more detailed information as, for example, the server to which the requests have been sent. A memento can be very simple, containing just the essential data of the requests issued by the Mh, or more complex, containing the atomic requests generated by the Mh requests, the sever to which the request was sent to, etc. For more details on mementos the reader is referred to [3].

If a second request is sent to the Mss by the Mh before the first one is answered, it is directed to the proxy. The proxy then updates its state, and directs the new request to the server. If the Mss is responsible for constructing the mementos, the memento of the new state of the proxy is returned to the Mh.

When a result comes back to an Mss it is delivered to the proxy which, in turn, sends it back to the Mh. Optionally, along with the answer to the request, the proxy sends a new memento, reflecting the new sate. If no aknowledge comes after a set time, the result is re-sent to the Mh.

When an Mh migrates from Mss_1 to Mss_2, it sends a *greet* message to Mss_2. This greet message is accompanied by the memento of the proxy that Mh was using in Mss_1. Mss_2 then creates a new proxy using the state information contained in the memento and re-sends the pending requests to the sever. Each request is uniquely numbered[1]. If the server has already serviced the request, it just process it again, sending the answer. If the server has the request queued, but not answered, it redirects the answer to Mss_2, instead of Mss_1.

There is no hand-off protocol, the proxy in Mss_1 is just starved. Distributed garbage collection protocol ensures that starved proxies are eventually killed. Garbage collection can be implemented as a full distributed algorithm [4], or some alternative schemes can be used. One option is setting a time limit on the proxy for waiting acknowledgements, after which the proxy is destroyed. This does not affect reliability, as the Mh carries the memento which can be used to reconstruct the destroyed proxy, if needed. A second choice is for the server to keep a proxy-id/Mss list and, when a new request for a pending message comes, warn the originalMss that its proxy should be destroyed.

When a proxy receives the answer to the last pending request, a null memento is sent back to the Mh. When a migrating Mh sends a null memento as part of the greet message, no proxy is created on the newMss. Proxies with no pending requests are killed by the system.

This protocols insures delivery of the requests even on the event ofMss failure. Since the Mh always carry a memento with the latest Proxy state, it is always possible to reconstruct the old proxy in the newMss. Contrary to RDP, this protocol also ensures safety in the event of inter-Mss communication failure.

Figure 1 shows an Mh that sends a request (Req-1) to Mss_1 and moves to Mss_2 before receiving the answer (Ans-1). AtMss_2 it sends a new request (Req-2) and receives the answer to both the first and second request (Ans-1 and Ans-2, respectively).

4 Related Work

The protocol presented in this paper is a development on RDP[1]. The main difference is that RDP assumes that the Mss's are reliable and do not fail, and that the communication between Mss's is also reliable and in causal order. With the reliability assumption they are able to avoid proxy migration (or re-creation): in RDP the proxy stays in the initial Mss until all pending requests are answered. Meanwhile, when a Mh moves from one Mss to another, the greet() message starts a handshake protocol between the new Mss and the host Mss for the proxy that guarantees that the proxy in the is informed of the

[1] An easy scheme to achieve this is to append the Mh number to a request number

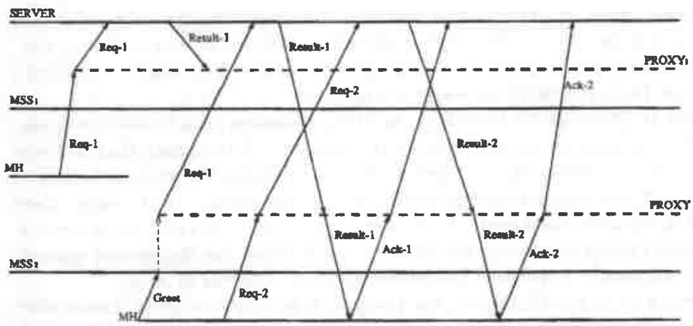

Figure 1: Time line of RDP-R

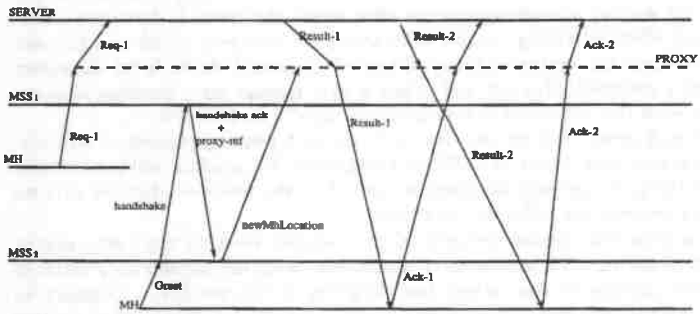

Figure 2: Time line of RDP

Mh's new location, forwarding all results to that address. In RDP the *Mh* does not need to keep a memento of the pending requests, reducing memory requirements. However, it potentially increases communication costs, as all pending requests (and new ones made while the proxy in the old *Mss* is alive) will have an extra indirection point, the old *Mss*, as it is the old proxy that is in charge of forwarding the answers to whichever is the current location of the *Mss*. Also, the proxy in RDP is more complex, as it needs to keep track of the *Mh*'s current *Mss* location. Figure 2 illustrates the functioning of RDP.

5 Discussion

The protocol presented in this paper guarantees delivery of results with *at-least-once* semantics, if there is always an *Mss* available to the *Mh*. In case of *Mss* failure or in case the communication with the current *Mss* becomes impossible for a set time, the Mh can just contact an alternative Mss and reinstate the requests.

This protocol is flexible enough to support a series of variations on policy implementation. There are alternate (and interchangeable) ways of deactivating starved proxies, constructing mementos and redirecting the server results to the new Mss. All the variations of the protocol should perform in the event of Mss failure. Also, the presence of a memento in the Mh makes it safe for Mss to implement more flexible proxy management policies, destroying proxies that are unable to communicate with the Mh for long periods of time, even if it is just a long communication failure. The Mh just needs to re-send the memento for the proxy to be reconstructed.

Safety however does not come free of cost. Each time a Mh migrates the resources used by the old proxy are kept in the old Mss until the garbage collection procedures determine it should be killed. Also, depending on the memento construction option used, each request answer that is send from the Mss to the Mh also have to carry now a memento of the proxy. The extra communication cost in the greet message (the Mh has to send the memento) is fully compensated by the absence of a hand-shake procedure between the new Mss and the old one. This protocol also imposes a potentially heavier load on the server, as it must re-send results of a moved Mh, or screen the incoming requests for filtering duplications.

The RDP-R will be implemented as a prototype system in the scope of the Sidam project and its performance will be measured in various patterns of mobility and compared to the performance of RDP. Intially we will simulate mobility through random communication between distributed processes in a Linux network. In the future all the protocols withing the Sidam project will be implemented in a real wireless environment.

6 Acknowledgements

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