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par

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Intitulée

Ordre Causal dans les Environnements Mobiles

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Abstract

Since, the send and receive of messages are the unique way enabling processes to cooperate and exchange data, then tracking causality between messages in the aim of efficient passing of messages with appropriate semantics is of great importance. To this end, the research community proposed the idea of "*causal message ordering*". The causal ordering concept has a considerable interest in the design of distributed systems and finds its application in several domains, such as management of replicated database updates, determining global snapshot, resource allocation, shared distributed memory, distributed virtual environments, teleconferencing, stock trading, collaborative applications, delivery in multimedia systems, etc.

As far as the mobile computing environment is considered, the design of causal ordering protocols must deal with the new characteristics of this environment, such as mobility, resource constraints on mobile hosts and the limited bandwidth of wireless links.

In distributed computing systems (either conventional or mobile), processes are often organized into groups for supporting various applications, such as computer-supported-cooperative work (CSCW), replicated services, news groups, etc. Group-based communication has proven an important paradigm for developing such distributed systems. In Group Communication Systems (GCS), causal ordering protocols are an essential tool to exchange information. However, achieving ordered delivery of messages for group communication in mobile environment is complicated by the fact that a group composition may change by the join of new members, the leave of existing members and the migration of members between cells.

In this work, we focused on *causal ordering* in mobile environments considering the different kinds of communication (unicast, broadcast and multicast) and dynamic groups.

The emerging trend towards multicast applications in which there is a need to communicate with several other hosts simultaneously (e.g. dissemination applications, collaborative applications, fault tolerant applications, conversational applications, etc.), drove us to make our first contribution. In this proposal, we tried to get benefit from the important characteristics of our unicast protocol (*Mobi_Causal*), such as elimination of unnecessary inhibition delay, low message overhead and scalability, in order to extend it

to allow multicast communication among a static group of MHs and which can fill gaps of existing protocols, especially in terms of control information's size appended to each message. The proposed protocol (*MMobi_Causal*) retains all these interesting characteristics. It provides an optimal communication overhead without causing inhibition effect in the delivery of messages. This optimality is reached using the knowledge of *immediate dependency relationships* between messages and transmitting each message with only the relevant information to compliance with the causal order in the delivery of messages. The protocol is proved to satisfy the safety, the liveness, and the exactly once delivery properties.

Our second contribution is based on our intuition that developing a protocol dedicated to causal broadcast should be more interesting than using a multicast protocol to ensure this broadcast, especially in terms of *control information*'s size appended to each message. The proposed solution (*BMobi_Causal*) proves the advantage of developing a *dedicated* causal broadcast delivery protocol based on *process behavior's awareness*. The originality of our proposal lies on showing how the rather well known behavior of a process can influence the control information's size. We showed that by viewing the behavior of the execution in the sense that the reaction to occurring events is *instantaneous*, tracking the dependency between messages is possible by only keeping information about the message's *immediate predecessor*. Hence, causal broadcast delivery of messages can be easily achieved in a mobile group with a small message overhead. The proposed protocol keeps all the interesting characteristics of our unicast protocol (*Mobi_Causal*). It outperforms its counterparts with respect to communication overhead (its message overhead is $O(1)$). The protocol is also proved to satisfy the safety, the liveness, and the exactly once delivery properties.

The last contribution was devoted to the extension of the two proposed protocols to support dynamic groups while guaranteeing causal consistency. The novelty of our contribution lies in considering the leave and join requests as *data messages*. Then, a control information is appended to these messages and they will be ordered with data messages. The idea of ordering the join/leave requests with regular messages guarantees a causal consistence property that is of a great importance of applications do not needing strong ordering (like total order) requirements for messages. Moreover, it makes the installation of a view fully decentralized and without need to a coordination phase which is a very important advantage, even more in mobile environments. One important property guaranteed by our view management procedure is the *virtual synchrony* semantic. This semantic allows group members, that survive the same group changes, to know for certain that they have delivered exactly the same set of messages. By ensuring that processes deliver the same set of messages in each view, this allows them to maintain consistency across membership changes.

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