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Design and analysis of a fault tolerant hybrid mobile scheme

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Abstract

Mobile computing systems provide users with access to information regardless of their geographical location. In these systems, Mobile Support Stations (MSSs) play the role of providing reliable and uninterrupted communication and computing facilities to mobile hosts. The failure of a MSS can cause interruption of services provided by the mobile system. Two basic schemes for tolerating the failure of MSSs exist in the literature. The first scheme is based on the principle of checkpointing used in distributed systems. The second scheme is based on state information replication of mobile hosts in a number of secondary support stations. Depending on the replication scheme used, the second approach is further classified as a pessimistic or an optimistic technique. In this paper, we propose a hybrid scheme which combines the pessimistic and the optimistic replication schemes. In the proposed scheme, an attempt is made to strike a balance between the long delay caused by the pessimistic and the high memory requirements of the optimistic schemes. In order to find the best ratio between the number of pessimistic to the number of optimistic secondary stations in the proposed scheme, we used fuzzy logic. We also used simulation to compare the performance of the proposed scheme with those of the optimistic and the pessimistic schemes. Simulation results showed that the proposed scheme performs better than either schemes in terms of delay and memory requirements.

Keywords: Fault tolerance; Mobile computing; Fuzzy logic; Checkpointing; Mobile support stations; Pessimistic replication; Optimistic replication; Hybrid replication

1. Introduction

The increasing interest in the use of small portable computers, wireless networks, and satellites, caused a noticeable move toward supporting mobile computing. In order to support user mobility, the user is provided with wireless interface to other mobile and/or fixed users. The significant growth of worldwide wireless communications, together with services development, points to the advancement towards cost-effective and more

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reliable mobile communications systems [11]. Two entities are important in a mobile communication system. These are the set of *static hosts* and the set of *mobile hosts*. A *mobile host* (MH) can retain its network connection while moving [3]. Static hosts include *stationary hosts* (SHs) and *mobile support stations* (MSSs) [4]. MHs communicate with *base stations* through wireless channels while MSSs are connected via a wired network [27].

The state information of a MH is usually stored in the supposedly stable storage of its mobile support station [27,8]. This makes an MH highly dependent on its MSS. When a MSS fails, the state information of a *live* MH stored in that MSS is potentially lost [3]. This causes the MH to become inactive waiting for the recovery of the MSS. The downtime of a MSS may be long and hence the time for recovery can be unacceptable [3]. It is therefore, necessary to have a fault tolerant mobile computing environment: one which provides uninterrupted service despite the failure of MSSs. Two schemes to tolerate failures of MSSs have been proposed in the literature [3]. These schemes are called *optimistic* and *pessimistic* replication schemes [3,29]. In both schemes, state information of an MH is replicated to a number of other MSSs, called *secondary mobile support stations* (SMSSs). When a MSS fails, MHs registered under it can switch to one of the SMSSs to continue their operation. Thus, the affected MHs do not need to wait for the failed support station to recover. The optimistic and the pessimistic schemes differ in the way in which the replication is done.

A hybrid scheme that combines the advantages of optimistic and pessimistic schemes for tolerating failure of mobile support stations was proposed in [1]. This hybrid scheme was able to find low acknowledgement delays and low storage requirement, compared to those of the pessimistic and optimistic schemes respectively.

For this paper, performance analysis of the hybrid scheme was conducted. The paper is organized as follows. Section 2 provides some background material. A brief introduction to fuzzy logic is provided in Section 3. Existing techniques for achieving fault tolerance in mobile systems are reviewed in Section 4. The proposed hybrid scheme is presented in Section 5, along with a detailed explanation of the system operation. Since the hybrid scheme has two objectives to optimize, which are minimizing acknowledgement delay and minimizing memory storage capacity, we have used fuzzy logic to combine these objectives into one function. The process is explained in Section 6. Simulation results and comparisons are presented in Section 7. The paper is concluded in Section 8.

2. Background material

A mobile computing network is a distributed environment consisting of two main entities: *static* and *mobile* hosts. A mobile host (MH) can retain its network connection while moving [3]. An example of a mobile computing environment is shown in Fig. 1. A mobile support station (MSS) is a static host capable of communicating with MHs as well as with other MSSs. A *cell* (see Fig. 1, dotted circles) is defined as the geographical area within which a MSS supports the MHs in its vicinity. MHs can communicate with their MSS directly

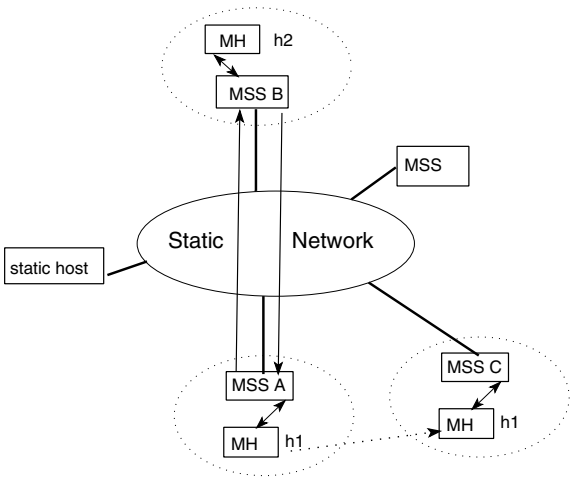

Fig. 1. A typical mobile computing environment.