Abstract

Adaptation is a desirable feature of any distributed system as it helps the system perform gracefully under different environments. In some cases, adaptation is required to ensure correct behavior of the system under different environments. In other cases, adaptation is used to ensure better performance when the environment changes. Any adaptive distributed system generally has two components. The first one is the *monitoring* part that monitors the state of the environment. The second component actually enables the adaptation by employing some mechanism. In this thesis we focus on mechanisms for enabling adaptation in distributed systems.

For many problems, more than one protocol exists such that each protocol works better in some specific environment. In such cases, adaptation can be achieved by dynamically switching between the protocols as the environment changes. However, in many cases it is also important to maintain certain properties of the system while switching from one protocol to another. In this thesis, we illustrate protocol-switching based adaptation in distributed systems by designing adaptive protocols for the single source broadcast and the mutual exclusion problems. In both cases, some guarantees on the performance of the system are provided even in the presence of switching.

For the single source broadcast problem, we propose crash-fault-tolerant distributed algorithms that dynamically switch between a BFS tree and a DFS tree for broadcast, both rooted at the single broadcast source. Algorithms are proposed for switching in both directions, i.e., from a BFS tree to a DFS tree and from a DFS tree to a BFS tree. We also study the same problem under transient failures. In this case we propose a self-stabilizing distributed algorithm for broadcast that switches from using one arbitrary spanning tree T to using another arbitrary spanning tree T'. For all the algorithms, it is shown that under

no failure, each broadcast message is eventually correctly delivered to all the nodes in spite of switching. Under arbitrary crash or transient failure, it is guaranteed that switching eventually terminates with the desired tree as the broadcast topology. As a special case, we also study the broadcast guarantees under a single crash or transient failure, as a single failure at a time may be more likely to happen in a well-designed system than an arbitrary number of failures.

Finally we propose an adaptive distributed mutual exclusion scheme that dynamically switches between two token based distributed mutual exclusion protocols, Raymond's algorithm that uses a fixed logical tree and Martin's algorithm that used a fixed logical ring. We propose switching algorithms for both directions. In each case it is shown that both mutual exclusion and no-deadlock properties are maintained at all times, even during switching.

Keywords: Adaptation, Protocol switching, Broadcast, Spanning tree, Crash failure, Self-stabilization, Mutual exclusion