9. Towards Robust Optimistic Approaches

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9.1 Introduction

Optimism is a well-known technique to enhance the performance of distributed protocols. Optimistic approaches exploit properties exhibited by the system with certain likelihood, (i.e., that certain kinds of scenarios will prevail over others) to outperform the corresponding conservative protocol. These properties are usually referred as optimistic assumptions (e.g., an optimistic assumption is that reliably multicast messages in a LAN are spontaneously totally ordered). When the optimistic assumption holds, the optimistic approach is more efficient than the conservative one. However, this gain usually implies a tradeoff. That is, if the optimistic assumption does not hold, the optimistic approach is less efficient than the conservative one. This is due to the need to undo or repair the incorrect actions and the dismissal of work already done. This is precisely the Achilles’ heel of traditional optimistic approaches. Therefore, what is crucial for an optimistic approach to be successful is that the resulting gains of optimism outweigh the penalties imposed by optimism failures.

Researchers have long recognized the potential benefits of using optimism and have proposed optimistic versions of conventional distributed protocols [9.2, 9.19]. However, despite the many optimistic approaches suggested in distributed computing, they are not that common in industrial applications. The main reason for this reluctance is that whenever the optimistic assumption fails, the protocol behaves worse than the conventional protocol. This behavior might imply more messages, or undoing part of the work. It is our opinion that to increase the applicability of optimistic protocols they need to be enriched with safeguards that limit the consequences of those scenarios where the optimistic assumptions do not hold. These safeguards make optimistic approaches more robust and efficient, and therefore, more applicable. As a consequence, in those periods during which the optimistic assumptions do not hold frequently enough, the system will not degrade to unacceptable levels.

In this paper, we try to point out the possible causes of the lack of success of some optimistic protocols, and show which directions can be taken to overcome these shortcomings in order to diminish the existing reluctance in industry for this kind of protocols. We think that optimistic protocols will play a crucial role in the upcoming wide-area distributed systems. Despite that bandwidth will grow more and more, latency will always be a problem in WANs due to physical limitations.

9.2 Traditional Optimistic Approaches

Replication. Computer clusters are the hardware platform of choice for many types of distributed information systems, and more concretely for replicated databases. These
systems usually have strong availability and consistency requirements. Reliable multicast [9.3] has become one of the main abstractions for building fault-tolerant distributed systems. More particularly, it has become a key building block for modern information systems. Unfortunately, and in spite of the intensive research carried out in the area, there is still a lot of reluctance in the information systems community to use such protocols on account of their performance (mainly the high latency). This reluctance has prevented its widespread use in some contexts such as replicated databases. In this paper, we will focus on optimistic protocols for distributed databases [9.2, 9.17], [9.9, 9.4], with special emphasis on those based on reliable multicast [9.16], [9.20, 9.1, 9.14, 9.10].

Typical measures of efficiency in an information system are throughput and response time. The latency introduced by reliable multicast, especially when total order and/or uniformity are provided, can have a severe effect on these efficiency measurements. Thus, in practice, designers opt for protocols that provide weaker guarantees but have a lower latency, especially in WANs.

The ideal would be a protocol exhibiting the strong guarantees provided by reliable multicast (i.e., providing total order and/or uniformity) but without the latency penalty typically associated with the implementation of these guarantees. One way to achieve this goal is by using an optimistic approach. One of such optimistic approaches is taken in [9.16], where the spontaneous total order exhibited by IP multicast in a LAN is exploited to reduce the latency of transaction processing in a replicated database. In [9.16] transactions are multicast to all sites. Multicast messages are totally ordered to ensure one copy serializability, the correctness criteria for replicated databases [9.2]. In this approach, multicast messages are delivered optimistically as soon as they are received [9.23, 9.22]. Thus, the database can start their processing in an optimistic fashion. When the total order of the multicast message is established, the message is definitively delivered to the database system. The time elapsed between the optimistic delivery and the definitive delivery is used to process (at least, partially) the message (transaction).

The caveat of such an optimistic approach is that it can result in a high number of transaction aborts (rollbacks) when the optimistic assumption does not hold. More concretely, when the load is high and messages are retransmitted due to buffer overruns, the order in which the messages arrive at different sites differs. Therefore, conflicting transactions can be executed in different orders at different sites. The corrective action needed when the optimism fails consists in aborting those transactions that have been executed optimistically following an order that do not comply with the total order and reexecute them.

Atomic Commitment. Distributed information systems use atomic commit protocols to ensure the atomicity of their operations. Well-known examples of atomic commit protocols are the two phase commit protocol (2PC) [9.7] or three phase commit protocols (3PC) [9.21, 9.12]. One of the intrinsic limitations of commit protocols is the incurred latency, involving several rounds of messages and forced disk writes. Some optimistic approaches have been proposed to overcome these limitations, such as the optimistic two phase commit protocol [9.17] or the OPT two-phase commit protocol [9.9].

The optimistic two-phase commit protocol [9.17] takes as optimistic assumption that the most likely outcome of the commit protocol is to commit the transaction. The