Extending Byzantine Fault Tolerance to Replicated Clients

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Abstract

Byzantine agreement protocols for replicated deterministic state machines guarantee that externally requested operations continue to execute correctly even if a bounded number replicas fail in arbitrary ways. The state machines are passive, with clients responsible for any active ongoing application behavior. However, the clients are unreplicated and outside the fault-tolerance boundary. Consequently, agreement protocols for replicated state machines do not guarantee continued correct execution of long-running client applications.

Building on the Castro and Liskov Byzantine Fault Tolerance protocol for unreplicated clients (CLBFT), we present a practical algorithm for Byzantine fault-tolerant execution of long-running distributed applications in which replicated deterministic clients invoke operations on replicated deterministic servers. To ensure consistency of execution, replicated clients agree on the result of each server operation. Our algorithm scales well to large replica groups, incurring constant communication latency with a linear number for messages, roughly double the latency and message count as CLBFT for unreplicated clients. Our protocol supports both synchronous and asynchronous clients, provides fault isolation between the client and server groups with respect to both correctness and performance, and uses a novel architecture that accommodates externally requested software upgrades for long-running replicated clients.

Keywords: Byzantine agreement, fault-tolerance, replication, replicated clients, replicated servers

20 pages, plus appendix   **This paper is eligible for the best student paper award.**

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