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The Management of Consistency in Fault-Tolerant File Systems

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Critical data are often replicated in distributed systems to protect them against site failures and network partitions or to allow higher access rates. This trend benefits from recent advances in computer network technology and reductions in the cost of storage media, which have made the replication of important files on several sites a cost-effective proposition.

The existence of several copies of the same file raises the issue of *file consistency*. It would be quite unreasonable to require the system users to be responsible for the consistency of data stored at multiple sites of a network. Distributed file systems implementing file replication need to enforce an access policy isolating their users from that issue and maintaining a consistent view of all replicated data under all possible circumstances. Several consistency protocols have been discussed in the literature, including token based schemes, active copy schemes and schemes based on quorum consensus. We still lack however a comprehensive study of the costs and performance of these consistency protocols in terms of their traffic overhead and on the restrictions they impose on file availability.

We have developed in recent years a replicated file system prototype to study these issues and to investigate the feasibility of more efficient consistency protocols. Our Gemini prototype [BMP87] runs on a network of **UNIX** machines linked by a subnet using the DARPA TCP/IP transport layer protocol. Because of its extremely modular conception, it provides an ideal test-bed for the study of consistency protocols. This project has already given birth to several novel consistency protocols including Dynamic Voting [DaBu85], Voting with Witnesses [Pari86a, Pari86b], Naive Available Copy [LoPa87, CLP87], Optimistic Dynamic Voting and Topological Dynamic Voting [PaLo88].

In our talk, we will briefly review these protocols and present the tools used to evaluate their performance [CLP87, PLG88] with respect to other consistency schemes such as Majority Consensus Voting [Elli77, Giff79] Available Copy [Good83], Lexicographic Dynamic Voting [Jajo87] and Regeneration [PNP86]. Our presentation will focus on two key issues. First, copy locations and network topology are to play a primary role in the selection of a consistency protocol for replicated data. Second, there is no need to compromise between file availability and network traffic overhead as all the protocols can be efficiently implemented by allowing them to use possibly out-of-date information.

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