

# *File-System Implementation*



As we saw in Chapter 10, the file system provides the mechanism for on-line storage and access to file contents, including data and programs. The file system resides permanently on secondary storage, which is designed to hold a large amount of data permanently. This chapter is primarily concerned with issues surrounding file storage and access on the most common secondary-storage medium, the disk. We explore ways to structure file use, to allocate disk space, to recover freed space, to track the locations of data, and to interface other parts of the operating system to secondary storage. Performance issues are considered throughout the chapter.

## **Bibliographical Notes**

The MS-DOS FAT system is explained in [Norton and Wilton (1988)]. The internals of the BSD UNIX system are covered in full in [McKusick and Neville-Neil (2005)]. Details concerning file systems for Linux can be found in [Love (2010)]. The Google file system is described in [Ghemawat et al. (2003)]. FUSE can be found at <http://fuse.sourceforge.net>.

Log-structured file organizations for enhancing both performance and consistency are discussed in [Rosenblum and Ousterhout (1991)], [Seltzer et al. (1993)], and [Seltzer et al. (1995)]. Algorithms such as balanced trees (and much more) are covered by [Knuth (1998)] and [Cormen et al. (2009)]. [Silvers (2000)] discusses implementing the page cache in the NetBSD operating system. The ZFS source code for space maps can be found at [http://src.opensolaris.org/source/xref/onnv/onnv-gate/usr/src/uts/common/fs/zfs/space\\_map.c](http://src.opensolaris.org/source/xref/onnv/onnv-gate/usr/src/uts/common/fs/zfs/space_map.c).

The network file system (NFS) is discussed in [Callaghan (2000)]. NFS Version 4 is a standard described at <http://www.ietf.org/rfc/rfc3530.txt>. [Ousterhout (1991)] discusses the role of distributed state in networked file systems. Log-structured designs for networked file systems are proposed in [Hartman and Ousterhout (1995)] and [Thekkath et al. (1997)]. NFS and the UNIX file system (UFS) are described in [Vahalia (1996)] and [Mauro and McDougall (2007)]. The NTFS file system is explained in [Solomon (1998)]. The Ext3 file system used in Linux is described in [Mauerer (2008)]. The

WAFL file system in [Hitz et al. (1995)]. ZFS documentation can be found at <http://www.opensolaris.org/os/community/ZFS/docs>.

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