Edith Cowan University

CSG1102
Operating Systems

Assignment 2

Implementation and operation
of the ext3 filesystem

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One of the most important parts of an operating system is the filesystem. It contains and manages critical data on disk drives, such as user configuration, user data and applications and of course, the operating system itself. The filesystem ensures that what is read from storage is identical to what was originally written. In other words, it ensures data integrity. A filesystem achieves data integrity by managing and storing not only the actual data, but also information about the data, or files in storage. It also stores and manages information about the filesystem itself. This information is known as metadata. User's trust the storage of data to the reliability and performance of the filesystem (Best, 2002).

But what happens to data when a system is improperly shutdown during file operations due to a crash or abrupt power loss? When Linux detects an improper shutdown, it signals a non-journaled filesystem (such as ext2) to perform a consistency check with `fsck` before booting into the operating system. This function scans the entire filesystem and attempts to fix any detected consistency issues that can be safely resolved. The `fsck` utility may take a considerable amount of time, depending on size of the filesystem, which can equate to serious downtime for the user (Jones, 2008). According to the developer of the ext3 filesystem, Tweedie (2000), Linux filesystems are growing in size, causing longer `fsck` process times.

Journaled filesystems negate the need for `fsck` (or equivalent in non *nix operating systems) to verify filesystem integrity, therefore greatly reducing downtime and increasing system availability in the event of an improper shutdowns (Best, 2002; Bost, 2012; Jones, 2008; Prabhakaran, Arpaci-Dusseau, & Arpaci-Dusseau, 2005; Tweedie, 1998, 2000). This is achieved by implementing a *log* or *journal* that records changes destined for the filesystem, which is stored in a circular buffer data structure. The changes recorded in the journal are committed to the filesystem periodically, and when an improper shutdown occurs, the journal is referenced as a checkpoint to recover unsaved information to avoid corrupted filesystem metadata (Jones, 2008). Therefore, a `fsck` scan of the entire filesystem is no longer required to determine consistency after an improper shutdown, as the journal is used for reference to determine integrity.

3   Ext3 discussion

3.1   Roots in ext2

In addition to creating a journaled filesystem for Linux, Tweedie (2000) describes one of the main goals in the design of the ext3 filesystem is the compatibility with the existing ext2 filesystem. This goal was justified, as much of the Linux user base was using ext2 at the time, and greater compatibility between the two filesystems would ensure seamless transition for users. This goal was successfully achieved, and an ext3 filesystem that is cleanly unmounted can easily be remounted as an ext2 filesystem. Conversely, an ext2 filesystem can easily be upgraded to ext3 *in-place*, while the volume is mounted (Bovet & Cesati, 2006; Robbins, 2001; Tweedie, 2000).

This backwards and forwards compatibility was achieved by using the same source code base for ext3 as ext2. Therefore, ext2 and ext3 share many common properties. For example, both filesystems use the same on-disk and metadata format. Ext3 also inherits ext2's `fsck` (Robbins, 2001; Tweedie, 2000). Although the desired effect of ext3 is to avoid the use of `fsck`, there are still times when it may be required, in the event that metadata is corrupted. Availability of `fsck`, with years of development further enhances the reliability of ext3, when compared to other journaled filesystems which do not have a similar capability (Robbins, 2001).

In order to implement journaling in ext3, an API external to the filesystem was developed, called the Journaling Block Device (JBD). Its main purpose is to implement "a journal on any kind of block device" (Robbins, 2001, p. 8). Tweedie (2000) asserts that the JBD is completely encapsulated from ext3. It does not know anything about how the filesystem works, and conversely, the filesystem does not know anything about journaling. The extent of ext3's knowledge of journaling is through *transactions*. The following section describes the journaling mechanics of ext3 in detail.

3.2   Journaling mechanics in ext3

The ext3 journal is stored in an inode (Robbins, 2001; Tweedie, 2000). An inode is an area on the disk where all the information about a file is stored. The actual file itself is not stored in an inode. Best (2002, p. 2) uses the analogy of a "bookkeeping file for a file", and asserts that an inode is in fact a file itself. The decision to store the journal in an inode contributes to the goal of backwards/forwards compatibility with ext2, and avoids the use of incompatible extensions to the ext2 metadata (Robbins, 2001). It is common for the journal to be stored within the filesystem itself, however it is possible to store the journal on a separate device or partition (Prabhakaran et al., 2005; Tweedie, 2000).

3.2.1   Journaling Block Device (JBD)

Journaling in ext3 is implemented by "hooking in" to the JBD API, which allows ext3 to communicate the modifications the filesystem will perform to the JBD as transactions. Ext3 also requests permissions from the JBD before modifying certain data on the disk, providing the JBD the opportunity to manage the journal on behalf of the ext3 filesystem driver (Robbins, 2001).

3.2.2   Transactions

Transactions are the main concept in journaled filesystems, which "corresponds to a single update of the filesystem" (Tweedie, 1998, p. 4). Similar to database transactions, a journaled filesystem transaction deals with a sequence of changes to the filesystem as a "single, atomic operation" (Best, 2002, p. 4). In other words, the entire sequence of a transaction must be completed, or none at all.

3.3   Creating a file in ext3

3.4   Updating a file in ext3

3.5   Recovery in ext3

4   Conclusion

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