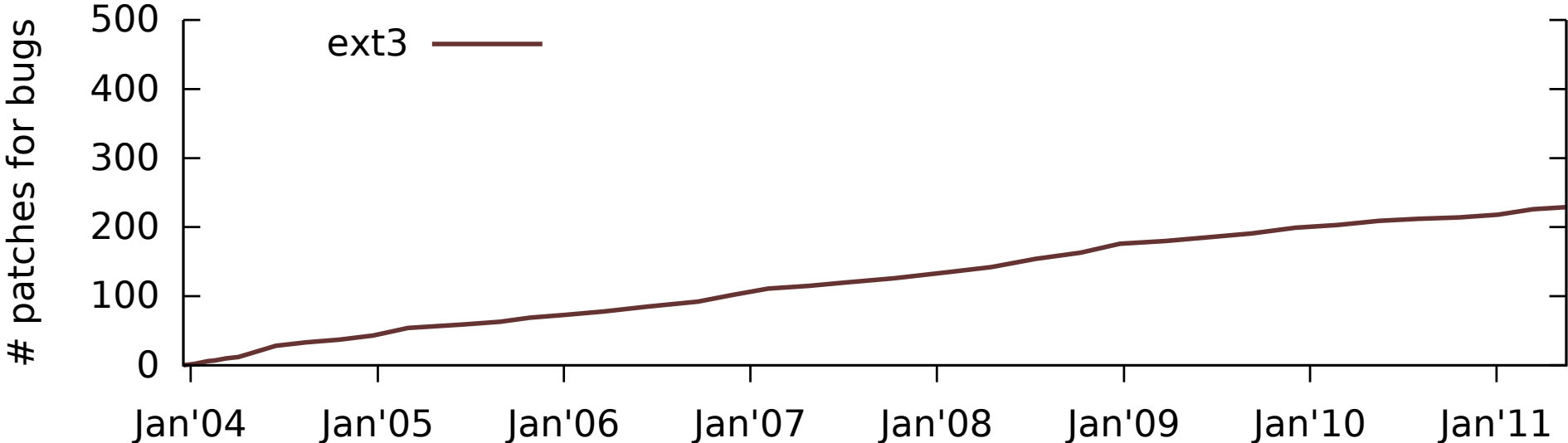


Example: file systems

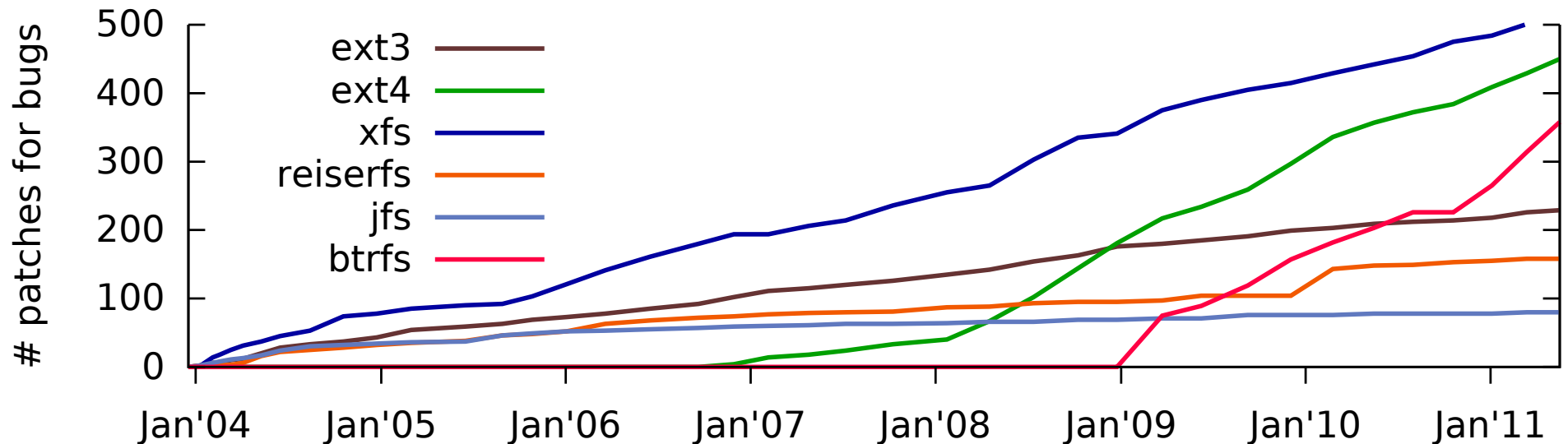
File systems are complex (e.g., Linux ext4 is ~60,000 lines of code) and have many bugs:



Cumulative number of patches for file-system bugs in Linux; data from [Lu et al., FAST'13]

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New file systems (and bugs) are introduced over time

Bug example: data corruption

```
commit 353b67d8ced4dc53281c88150ad295e24bc4b4c5
--- a/fs/jbd/checkpoint.c
+++ b/fs/jbd/checkpoint.c
@@ -504,7 +503,25 @@ int cleanup_journal_tail(journal_t *journal)
        spin_unlock(&journal->j_state_lock);
        return 1;
    }
+   spin_unlock(&journal->j_state_lock);
+
+   /*
+    * We need to make sure that any blocks that were recently written out
+    * --- perhaps by log_do_checkpoint() --- are flushed out before we
+    * drop the transactions from the journal. It's unlikely this will be
+    * necessary, especially with an appropriately sized journal, but we
+    * need this to guarantee correctness. Fortunately
+    * cleanup_journal_tail() doesn't get called all that often.
+    */
+   if (journal->j_flags & JFS_BARRIER)
+       blkdev_issue_flush(journal->j_fs_dev, GFP_KERNEL, NULL);
+
+   spin_lock(&journal->j_state_lock);
+   if (!tid_gt(first_tid, journal->j_tail_sequence)) {
+       spin_unlock(&journal->j_state_lock);
+       /* Someone else cleaned up journal so return 0 */
+       return 0;
+   }
+   /* OK, update the superblock to recover the freed space.
+    * Physical blocks come first: have we wrapped beyond the end of
+    * the log? */
```

Bug example: data disclosure

- Two optimizations in Linux ext4: direct data write and log checksum
- Subtle interaction: new file can contain other users' data after crash
- Bug introduced in 2008, fixed in 2014 (six years later!)

Author: Jan Kara <jack@suse.cz>

Date: Tue Nov 25 20:19:17 2014 -0500

```
ext4: forbid journal_async_commit in data=ordered mode
```

Option `journal_async_commit` breaks guarantees of `data=ordered` mode as it sends only a single cache flush after writing a transaction commit block. Thus even though the transaction including the commit block is fully stored on persistent storage, file data may still linger in drives caches and will be lost on power failure. Since all checksums match on journal recovery, we replay the transaction thus possibly exposing stale user data.

[...]