

## Other Approaches

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- Soft Updates
  - carefully order writes to ensure that pointed-to data blocks are written before the pointers
  - implementation requires detailed knowledge of file system data structures (more complex than with journaling)
- copy-on-write (COW)
  - never overwrite files and directories in place
  - instead write to unused locations, then periodically update the file system to refer to the new locations
- backpointer-based consistency (BBC)
  - every block includes a *back pointer*
    - e.g. data block contains pointer to the file's inode
  - instead of enforcing a particular write order, check forward and back pointers for consistency
- optimistic crash consistency
  - makes use of checksums and other techniques to detect inconsistencies