

Log Structured File Systems



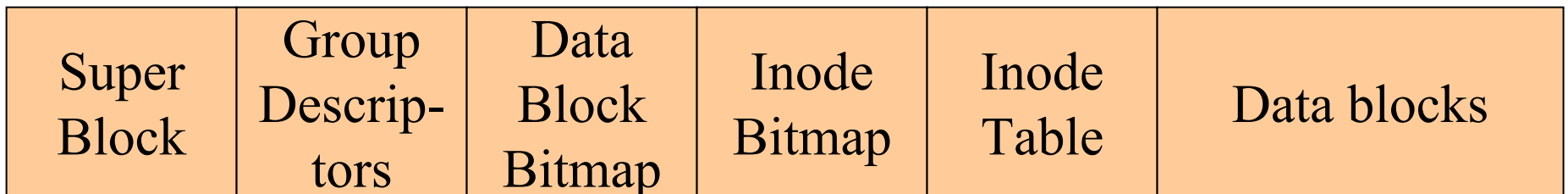
Motivating Observations

- Memory size is growing at a rapid rate
 - ⇒ Growing proportion of file system reads will be satisfied by file system buffer cache
 - ⇒ Writes will increasingly dominate reads



Motivating Observations

- Creation/Modification/Deletion of small files form the majority of a typical workload
- Workload poorly supported by traditional Inode-based file system (e.g. BSD FFS, ext2fs)
 - Example: create 1k file results in: 2 writes to the file inode, 1 write to data block, 1 write to directory data block, 1 write to directory inode
⇒ 5 small writes scattered within group
 - Synchronous writes (write-through caching) of metadata and directories make it worse
 - Each operation will wait for disk write to complete.
- Write performance of small files dominated by cost of metadata writes



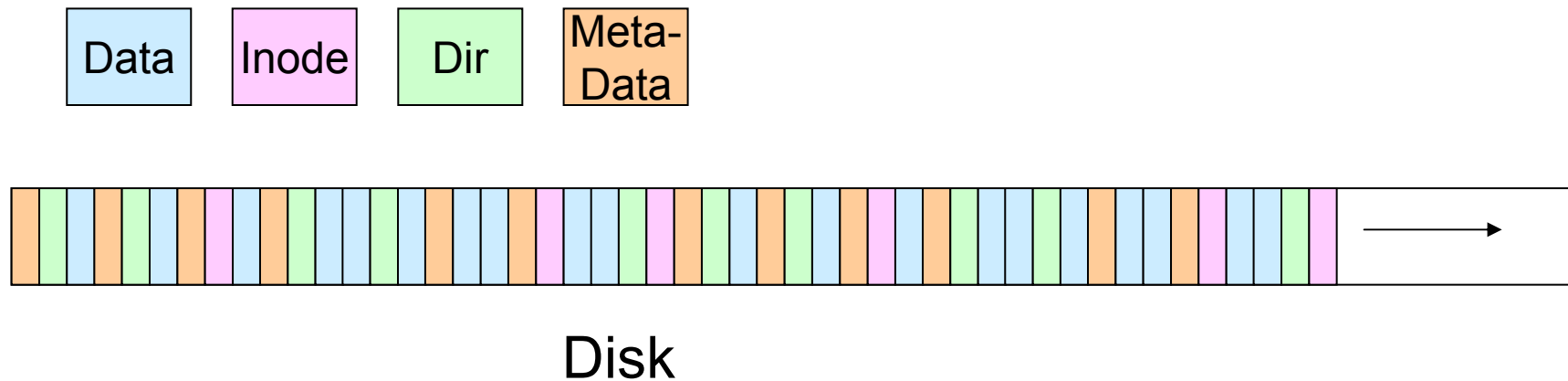
Motivating Observations

- Consistency checking required for ungraceful shutdown due to potential for sequence of updates to have only partially completed.
- File system consistency checkers are time consuming for large disks.
- Unsatisfactory boot times where consistency checking is required.



Basic Idea!!!

- Buffer sequence of updates in memory and write all updates sequentially to disk in one go.



Issues

- How do we now find I-nodes that are scattered around the disk?

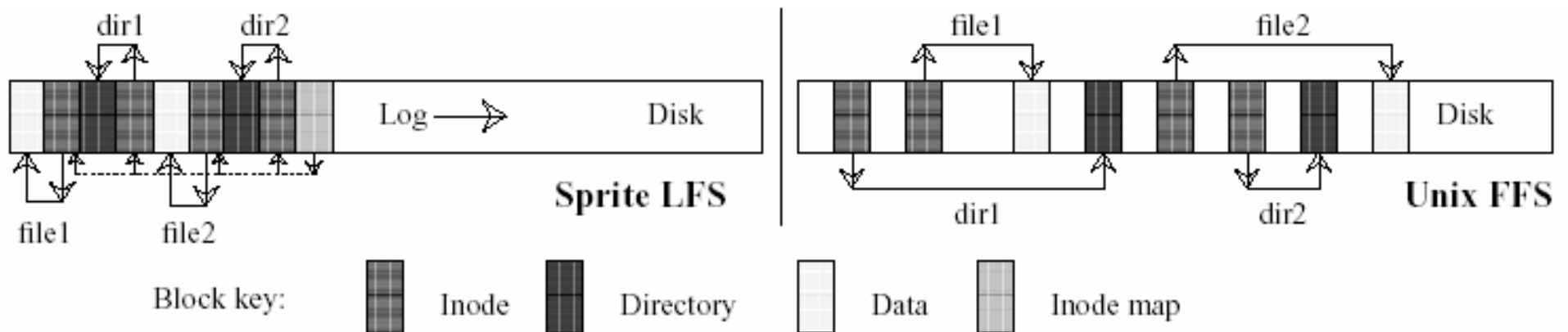
⇒ Keep a map of inode locations

- Inode map is also “logged”
- Assumption is I-node map is heavily cached and rarely results in extra disk accesses
- To find block in the I-node map, a two fixed location on the disk contains address of block of the inode map
 - Two copies of the inode map addresses so we can recover if error during updating map.



LFS versus FFS

- Comparison of creating two small files



Issue

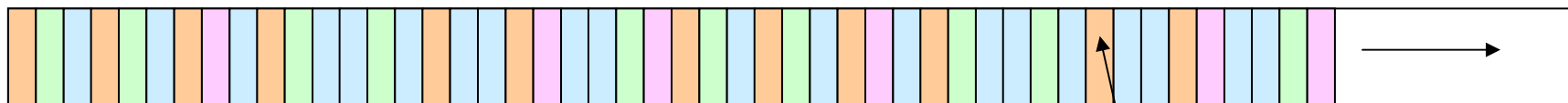
Disks are Finite in Size

- File system “cleaner” runs in background
 - Recovers blocks that are no longer in use by consulting current inode map
 - Identifies unreachable blocks
 - Compacts remaining blocks on disk to form contiguous segments for improved write performance



Issue Recovery

- File system is check-pointed regularly which saves
 - A pointer to the current head of the log
 - The current Inode Map blocks
- On recovery, simply restart from previous checkpoint.
 - Can scan forward in log and recover any updates written after previous checkpoint
 - Write updates to log (no update in place), so previous checkpoint always consistent



Checkpoint

Location



Reliability

- Updated data is written to the log, not in place.
- Reduces chance of corrupting existing data.
 - Old data in log always safe.
 - Crashes only affect recent data
 - As opposed to updating (and corrupting) the root directory.



Performance

- Comparison between LFS and SunOS FS
 - Create 10000 1K files
 - Read them (in order)
 - Delete them
- Order of magnitude improvement in performance for small writes

