FSTR

File System That Rocks

Tanuj Mittal
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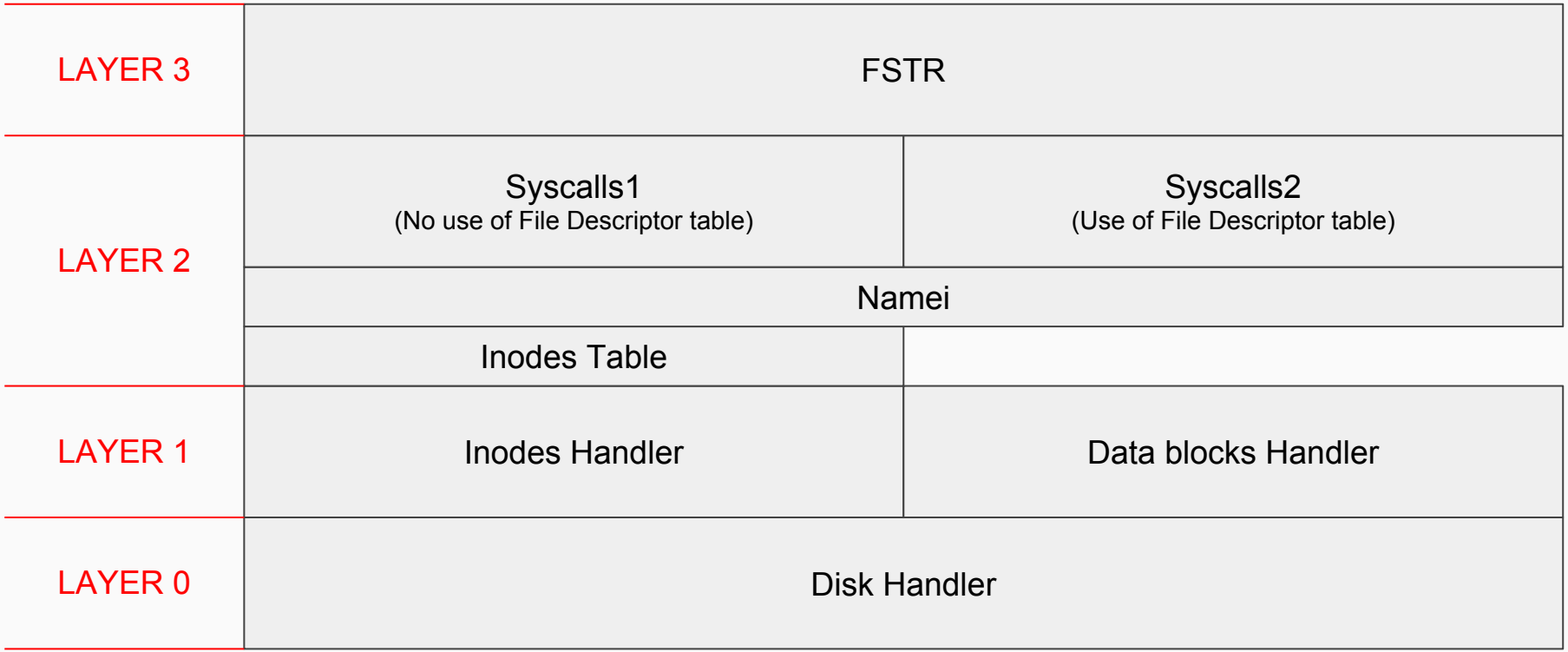
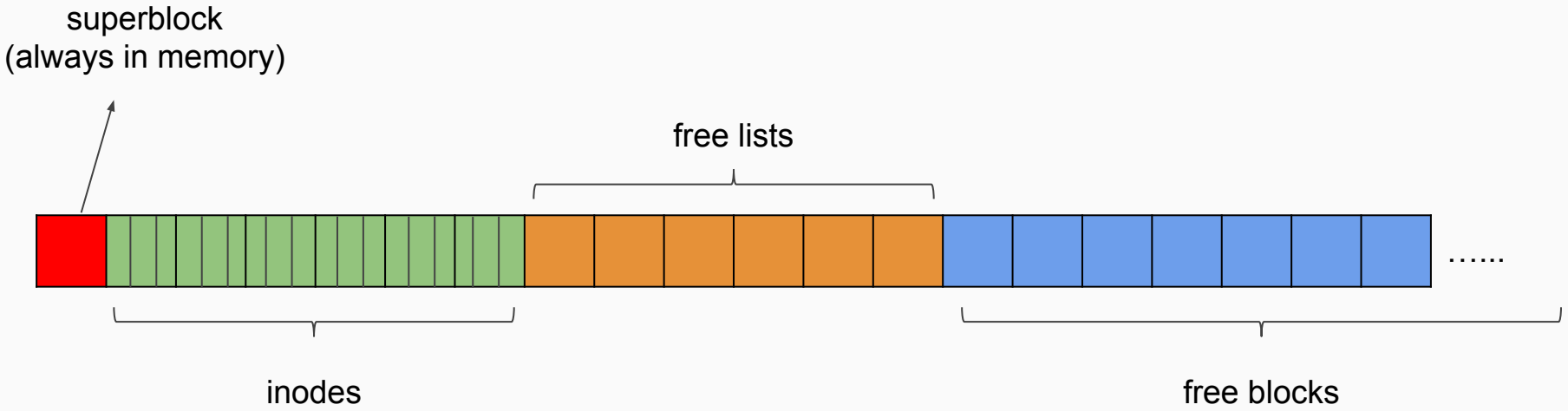
Presentation of layers



Layout of superblock, inodes, freelists



DONE BY mkfs.fstr UTILITY

Inodes Handler

Designed based on the algorithms presented in **The Design of UNIX OS** by **Maurice J Bach.**

Exposes three functions:

- **IGET -** fetches the given inode from disk
- **IPUT -** writes the given inode to disk; frees given inode if the number of links to it are 0 by calling IFREE
- **IALLOC -** searches for a free inode and allocates it

One internal function:

- **IFREE -** frees given inode and writes it to disk

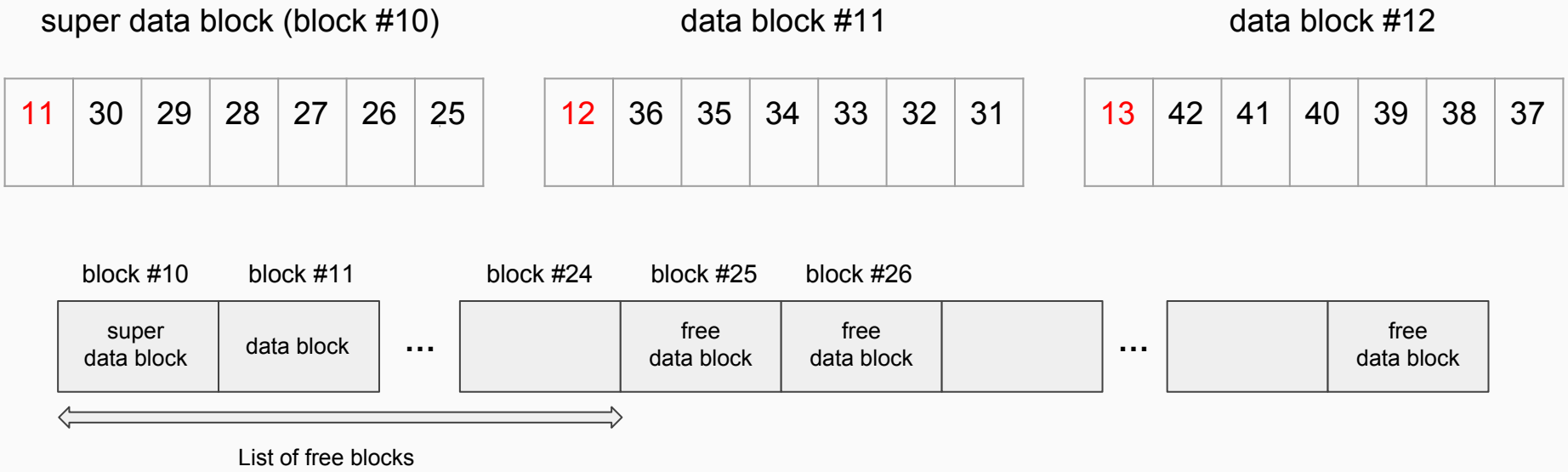
Inodes Handler

IGET (*inode_number, inode_buffer*)	**IPUT** (*inode*)	**IALLOC** (*inode_buffer*)	**IFREE** (*inode_buffer*)
• Read inode block (**BREAD**) • Copy inode from offset in block into *inode_buffer*	• If *inode->links = 0,* free all data blocks of file. **IFREE**(*inode*). Return • Read inode block (**BREAD**) • Copy *inode* into inode block at calculated offset • Write *inode* block (**BWRITE**)	• Find *next_free_inode* by linearly searching through all inodes. Return failure if not found. • **IGET**(*next_free_inode, inode_buffer*) • Set links_nb and default file type • **IPUT** (*inode_buffer*)	• Clear all fields of *inode_buffer* • *inode_buffer->TYPE = TYPE.FREE* • Read *inode_buffer* block **(BREAD**) • Copy *inode_buffer* to calculated offset • Write block (**BWRITE**)

How do we handle data blocks?

How do we handle data blocks?

How does the list of free blocks look like?



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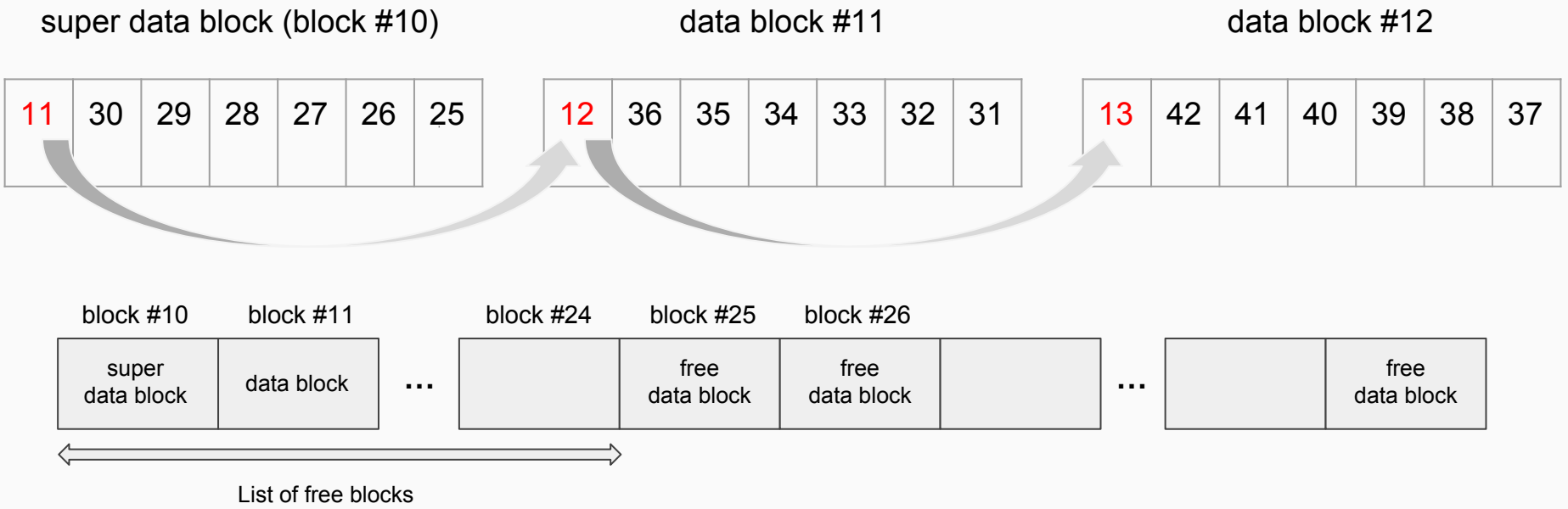


How do we allocate a data block?

How do we handle data blocks?

How do we alloc a data block?

super data block (block #10)

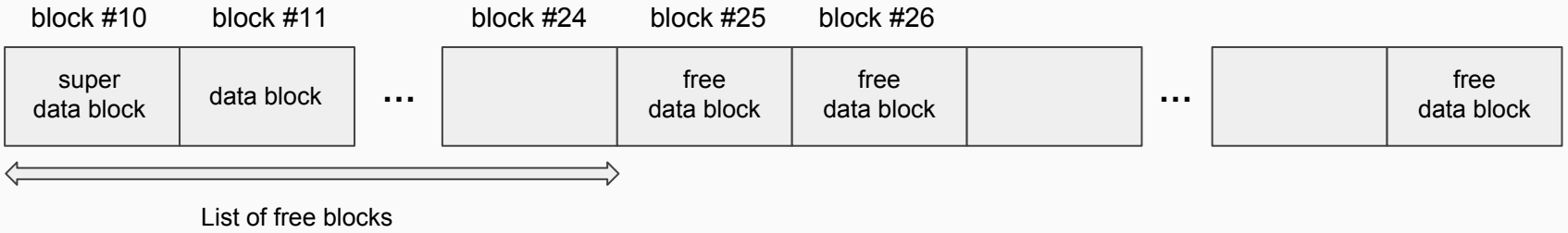
11	30	29	28	27	26	25

data block #11

12	36	35	34	33	32	31

data block #12

13	42	41	40	39	38	37



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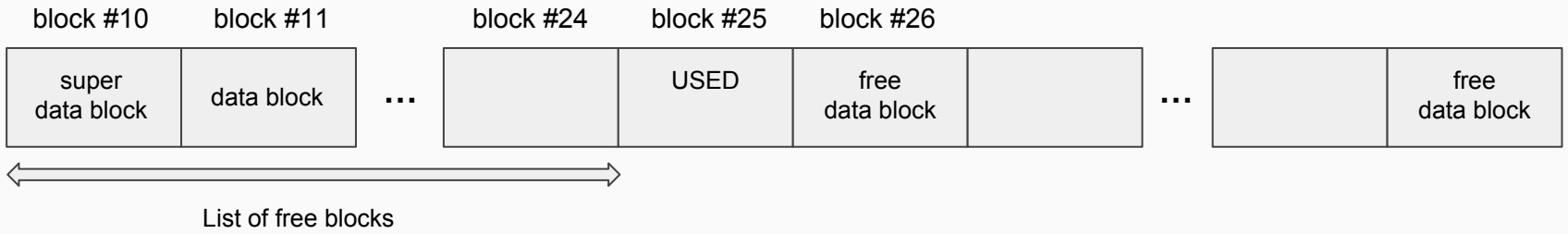

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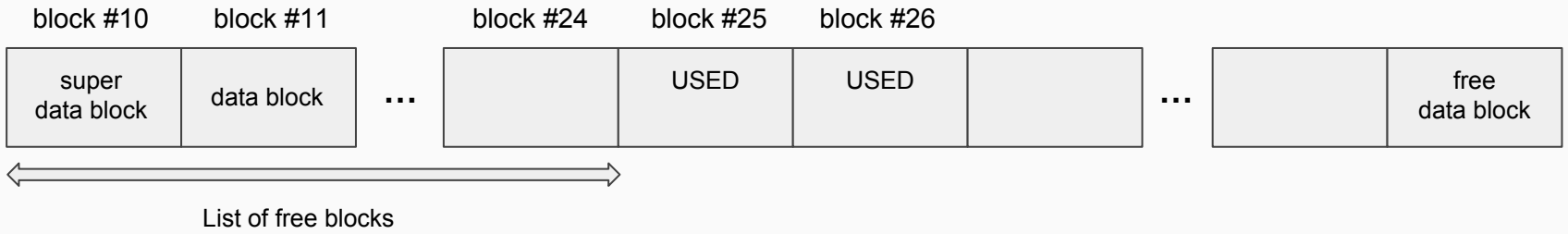

How do we handle data blocks?

How do we alloc a data block?
What happen for the last block number?

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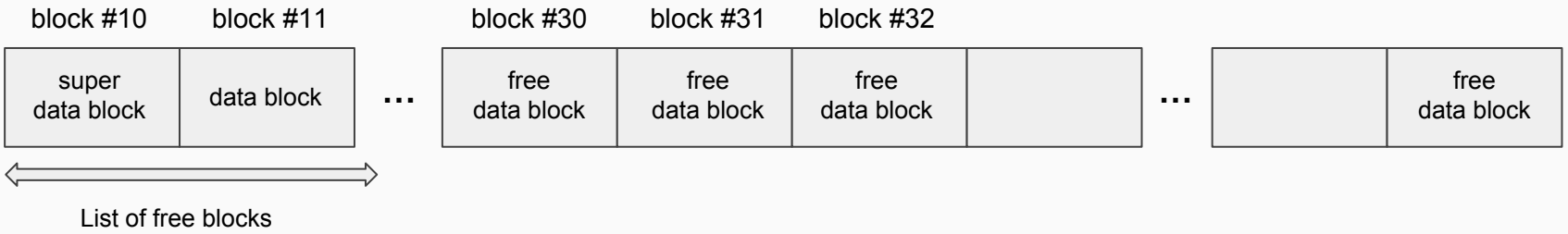

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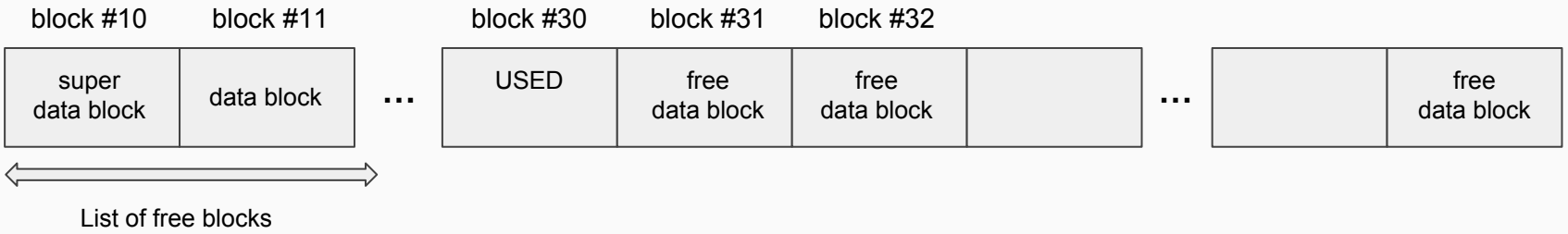

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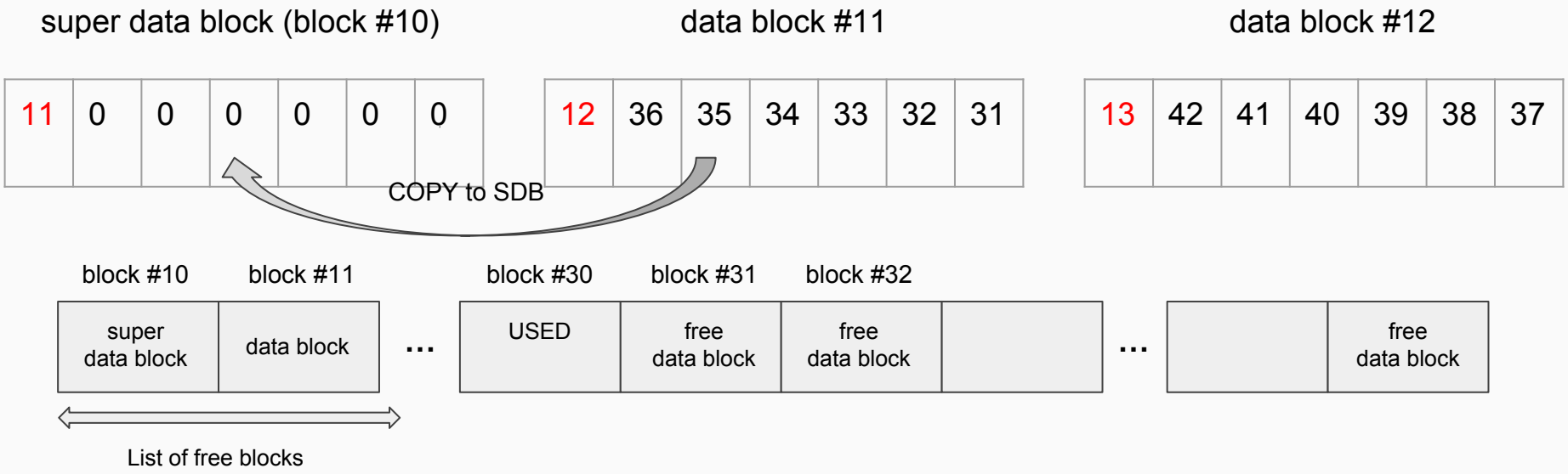

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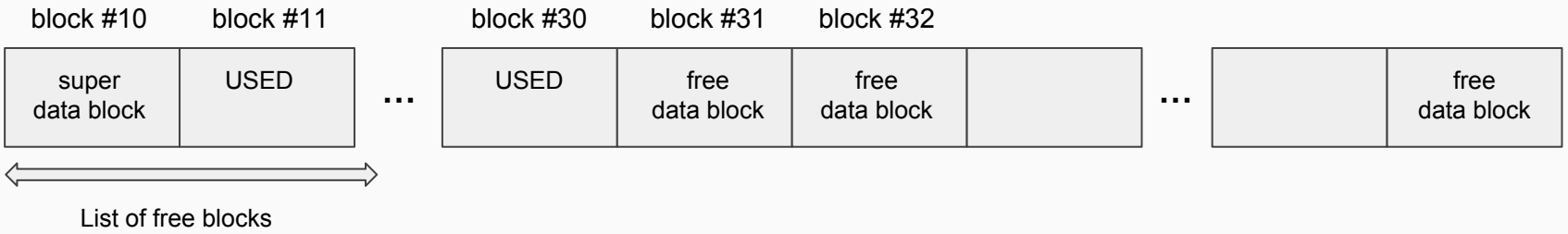

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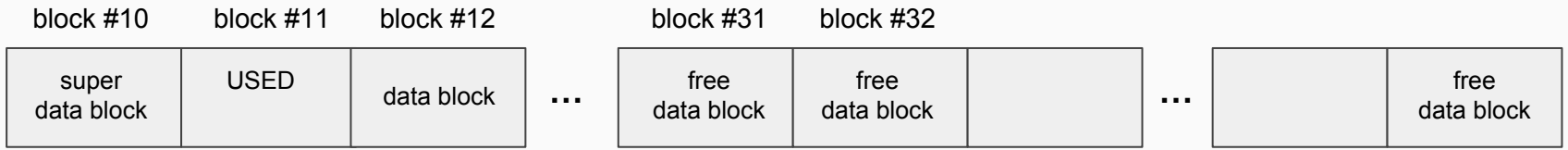


How do we free a data block?

How do we handle data blocks?

How do we free a data block?
e.g.: block #87

super data block (block #10)

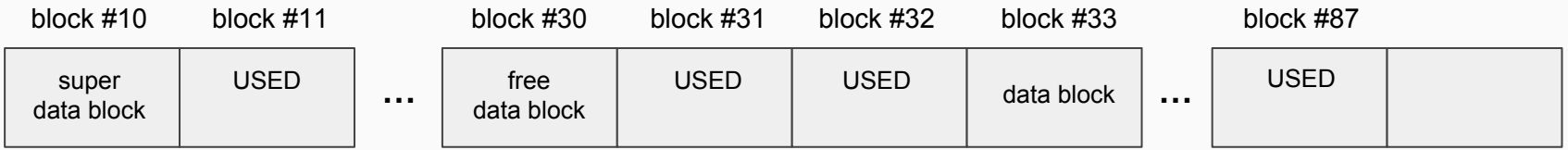
33	30	0	0	0	0	0

data block #33

73	38	45	51	65	64	63

data block #73

22	58	57	56	55	74	71



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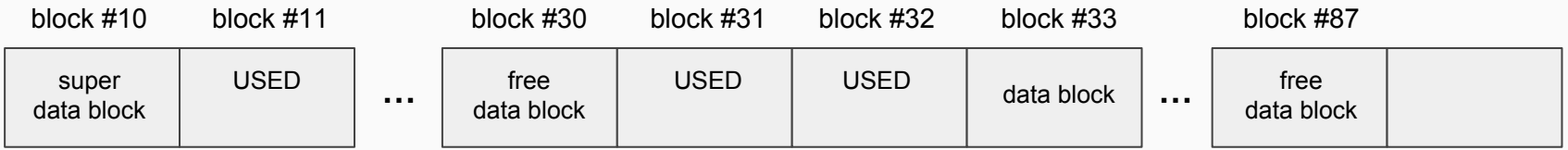


How do we handle data blocks?

How do we free a data block?
e.g.: block #15

super data block (block #10)

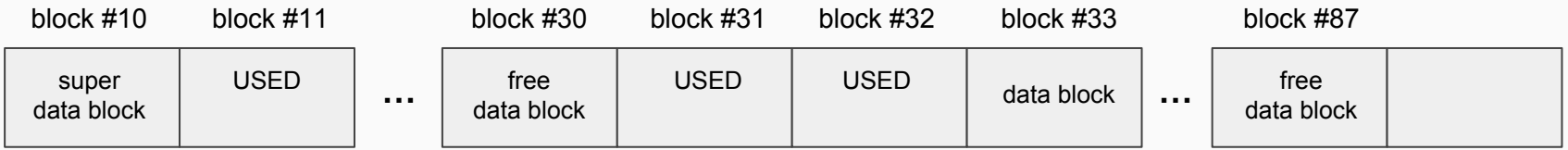
33	30	87	29	24	21	35

data block #33

73	38	45	51	65	64	63

data block #73

22	58	57	56	55	74	71



How do we handle data blocks?

How do we free a data block?
e.g.: block #15

data block #15

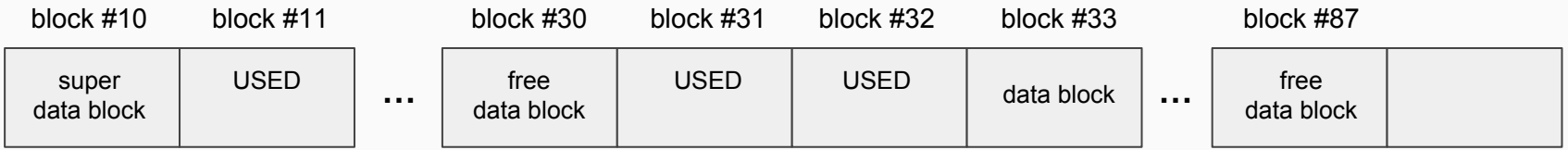
USED BLOCK

super data block (block #10)

33	30	87	29	24	21	35

data block #33

73	38	45	51	65	64	63



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block #10	block #11		block #30	block #31	block #32	block #33		block #87	
super data block	USED	...	free data block	USED	USED	data block	...	free data block	

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e.g.: block #15

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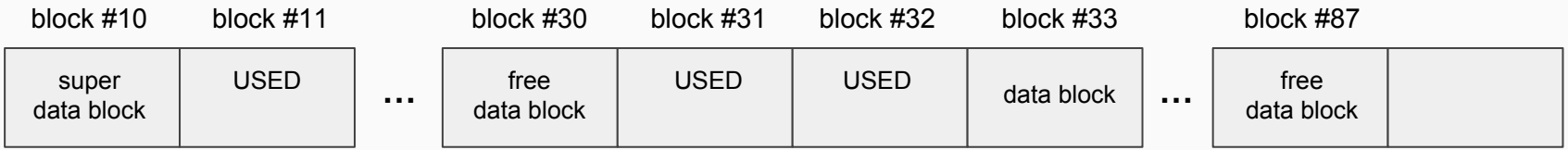

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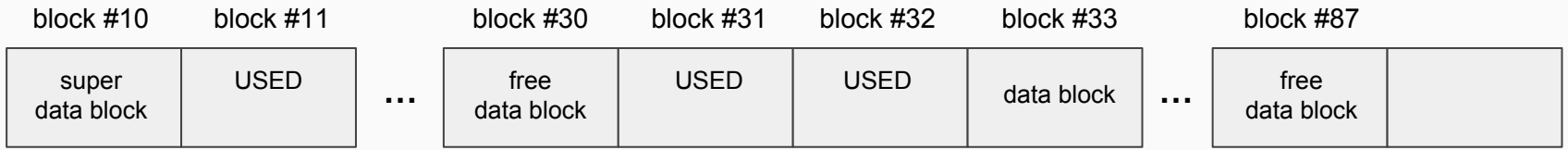
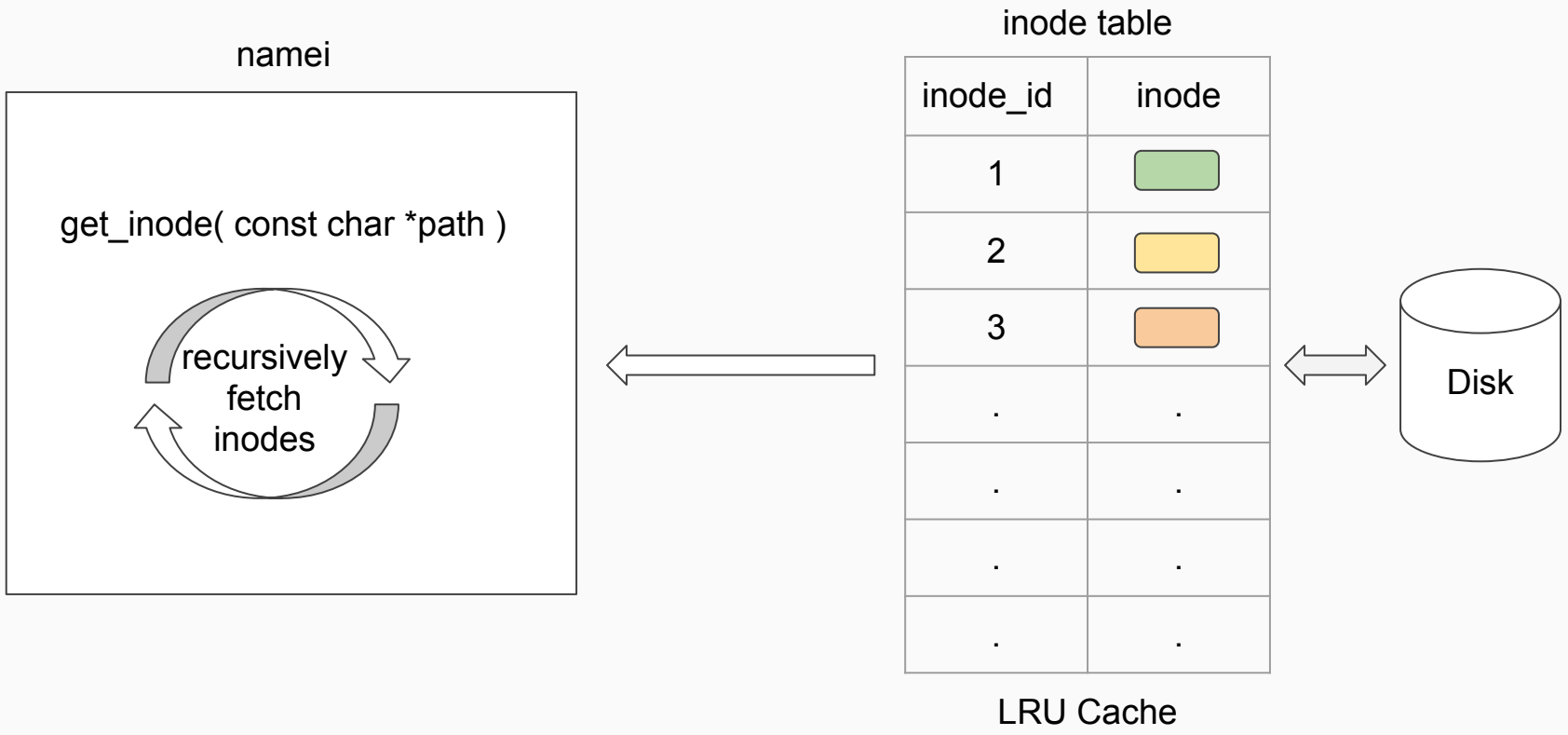


namei and inode table



Implementation of:

- int **syscalls1__mkdir**(const char *path, mode_t mode)
- int **syscalls1__mknod**(const char *path, mode_t mode, dev_t dev)

- int **syscalls1__readdir**(const char *path, void *buffer, fuse_fill_dir_t filler, off_t offset)
- int **syscalls1__rename**(const char *oldpath, const char *newpath)
- int **syscalls1__unlink**(const char *path)
- int **syscalls1__rmdir**(const char *path)

- int **syscalls1__lstat**(const char *path, struct stat *buf)
- int **syscalls1__utimens**(const char *path, const struct timespec tv[2])

- int **syscalls1__chmod**(const char *path, mode_t mode)
- int **syscalls1__chown**(const char *path, uid_t uid, gid_t gid)

How do we handle system calls?

Implementation of:

- int **syscalls2__open**(const char *path, int oflag, ...)
- ssize_t **syscalls2__pread**(int fildes, void *buf, size_t nbyte, off_t offset)
- ssize_t **syscalls2__pwrite**(int fildes, const void *buf, size_t nbyte, off_t offset)
- int **syscalls2__close**(int fildes)

These functions need to handle file descriptors

Tests

4 types of tests were performed on FSTR:

- **Unit tests** (per module) with Unity C Testing Framework
  http://www.throwtheswitch.org/unity/
- **Bash scripts** to do integration testing (thousands of files in a folder, recursive folders)
- **Manual testing** (creation/copy of big files ~1Gb)
- **Bonnie** (used for benchmarks and for testing)
  http://www.textuality.com/bonnie/intro.html

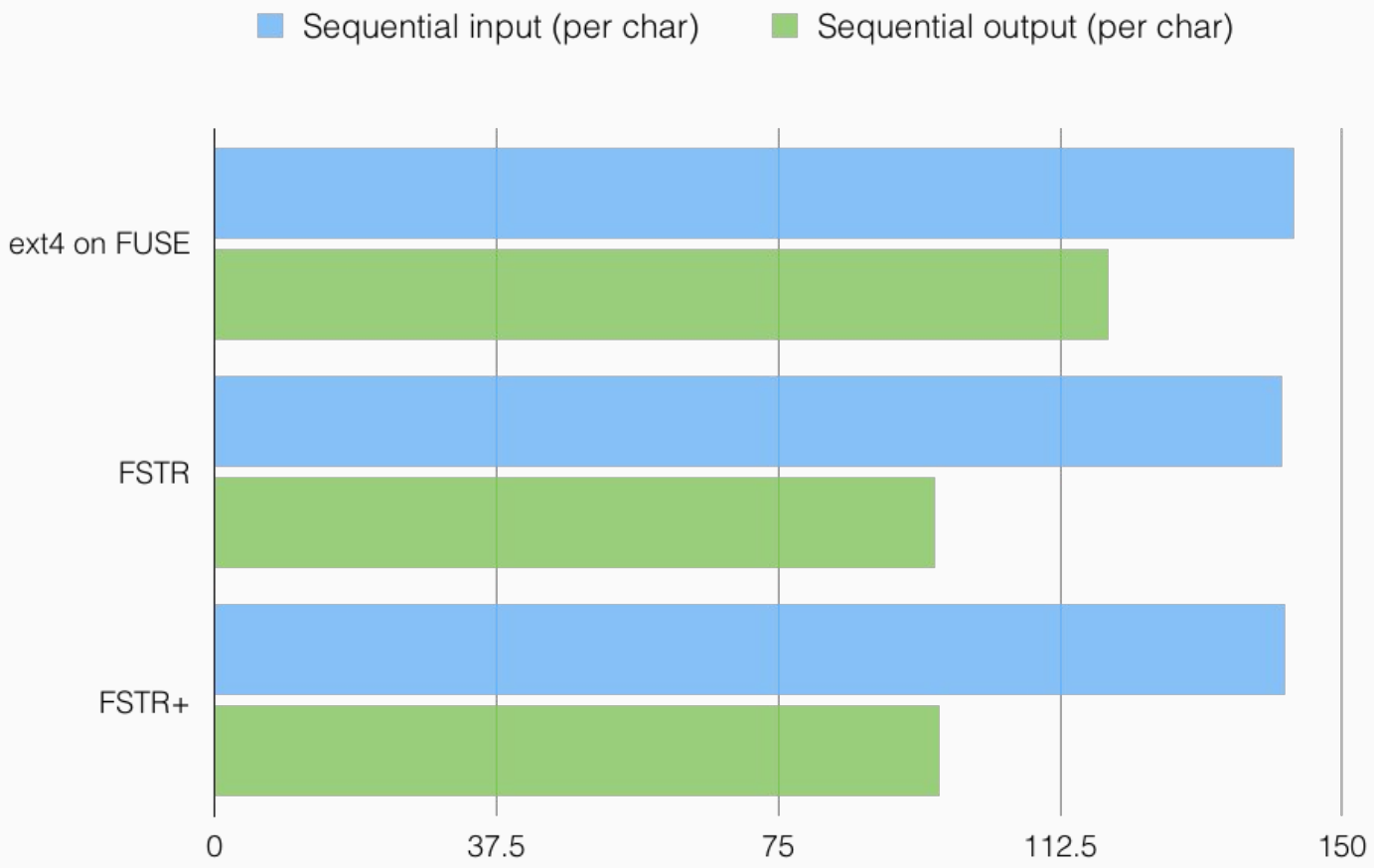
Travis CI to detect and avoid broken builds

It would have been impossible to debug without unit and layer testing

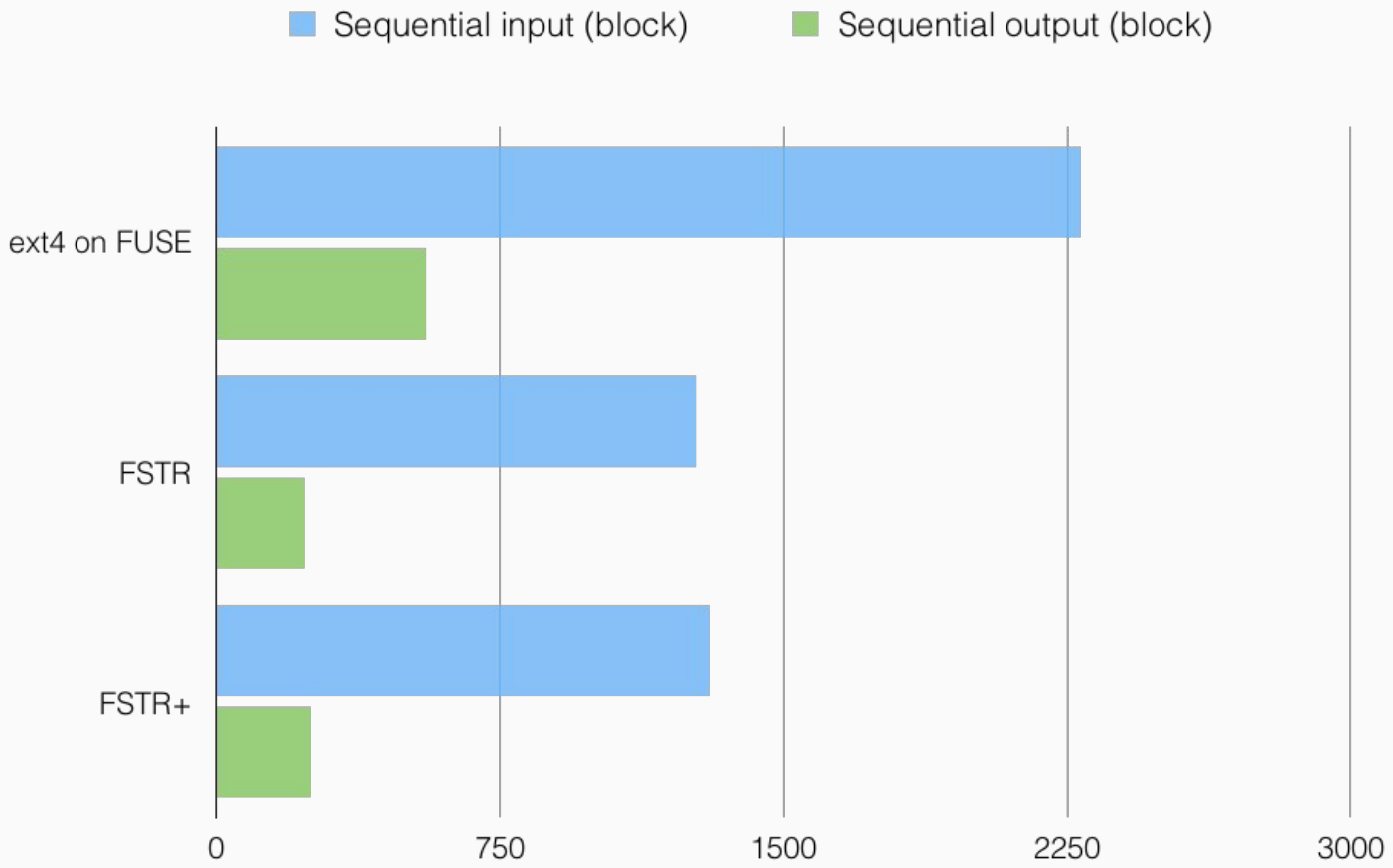
What Bonnie does

- a series of tests on a file of known size (100 MB default)
- **Sequential Output :** file written and rewritten using *putc()* and *write(2); tests the effectiveness of caching*
- **Sequential Input :** file read using *getc()* and *read(2)*
- **Random Seeks**

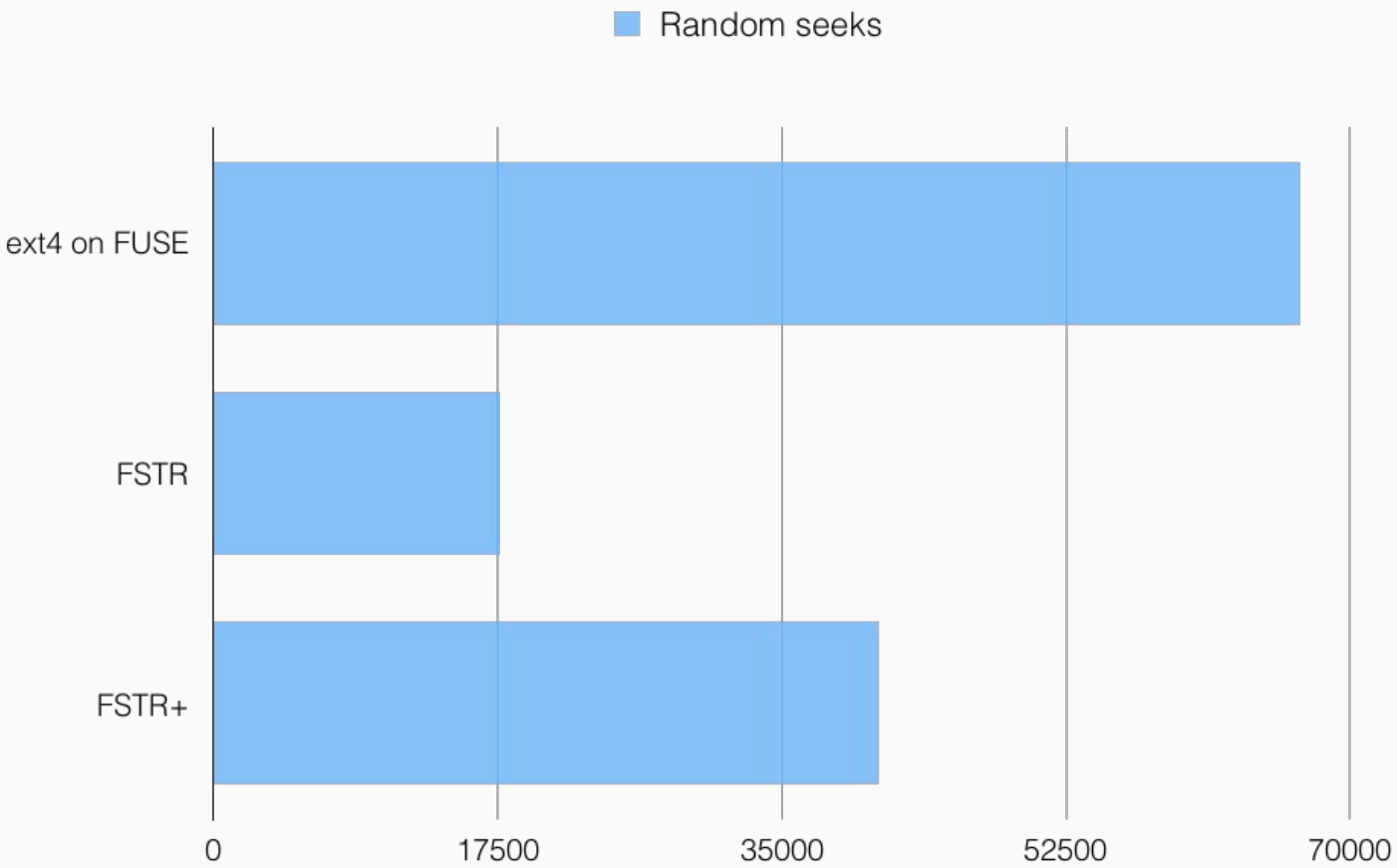
Benchmarks - *Sequential Character I/O*



Benchmarks - *Sequential Block I/O*



Benchmarks - *Random Seeks*



Key takeaways

- **layered development** makes unit testing easy
- **unit testing is effective** in catching bugs early on
- **stack variables > heap variables** for avoiding memory leaks
    - caller is responsible for allocation of memory
- **gdb is really helpful** for debugging

Questions?