COSI 131a:
Programming Assignment 3

Review Session

11/30/2015

What is this assignment about?

- Completing the design of a simple file system on top of a disk.
- Tasks:
  - Complete bitwise operations to fix the free space bitmap
  - Implement single-, double- and triple-indirection to support large files.
- Deadline: **Wednesday December 9, 11:55pm**.

File System

- Basic storage unit on disk?

- In your simulated disk we have NUM_BLOCKS blocks of BLOCK_SIZE bytes per block.
- A file may occupy multiple blocks depending on how large it is.
- Disk is presented as a very large file in your file system
- Beginning of the disk contains metadata. After metadata we have the actual data of the files.

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    - else if block is occupied position i has 0.

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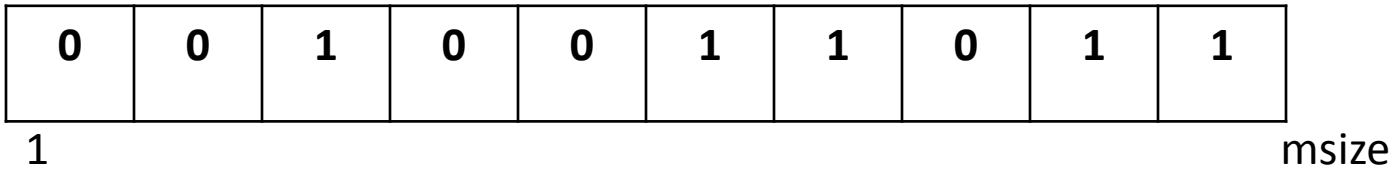
- Each position in the array represents what?
  - A block.
    - If position i in array has 1 then block i is currently free.
    - else if block is occupied position i has 0.
- If table is full of 0s disk is?
  - Completely full.
- Where do you think bitmap is stored?
  - At the metadata part of the disk.
- How many positions in the free space table?
  - NumBlocks.



Free Space

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- If tabl
  - C
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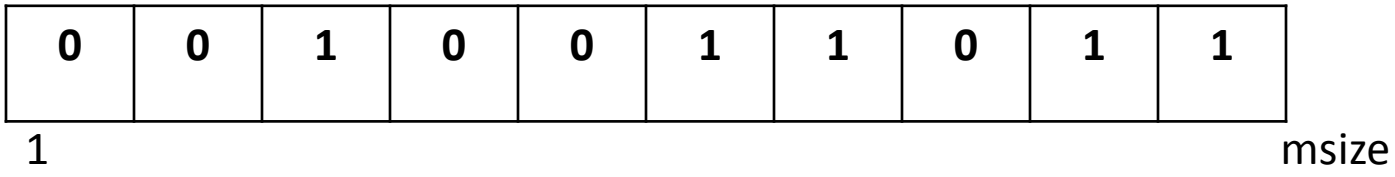
HOW CAN WE STORE BITS IN AN ARRAY IN JAVA?



Fix methods in Bitwise.java

- FreeMap is already implemented as an array of bytes.
- A byte is a primitive type in Java. A byte is made up of 8 individual bits. For example this is a byte: byte b = (byte)0x00; this is:“00000000”
- FreeMap depends on methods in Bitwise.java that you have to implement.
- These methods ask you to manipulate individual bits since each bit represents a block.
- Most methods ask to set a bit or clear a bit. Setting a bit means set it to 1 , clearing a bit means clear it to 0.

Example

```
private static final int bitmasks[] = {1, 2, 4, 8, 16, 32, 64, 128};

/**
 * Check to see if bit i is set in byte. Returns true if it is
 * set, false otherwise.
 */
public static boolean isset(int i, byte b) {
    //FIXME
}

/**
 * Check to see if bit i is set in array of bytes. Returns true if
 * it is set, false otherwise.
 */
public static boolean isset(int i, byte bytes[]) {
    //FIXME
}
```

Bitwise Operations in Java

- & :bitwise AND operation.
- | :bitwise inclusive OR operation.
- ^ :bitwise exclusive OR operation (XOR).
- ~ :inverts a bit pattern.

Logical Bitwise Operations

bit 1	bit 2	OR (|)	AND (&)	XOR (^)
0	0	0	0	0
1	0	1	0	1
0	1	1	0	1
1	1	1	1	0

Example

- Let's try to set the seventh bit of byte b = (byte)0x00 to be 1.
- \\b = "00000000"
- b *do_something* = 01000000

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- \\b = "00000000"
- b *do_something* = 01000000
- In Bitwise.java we have this: int[] bitmasks = {1, 2, 4, 8, 16, 32, 64, 128};
- You should think of a way to use it.
- THINK: What is the binary representation of 64?
- 64 in binary is:

  (0*2^7)+(1*2^6)+(0*2^5)+(0*2^4)+(0*2^3)…

  which is: 01000000
- b *do_something* = 01000000 ????

Example

- Let's try to set the second bit of byte b = (byte)0x00 to be 1.
- \\b = "00000000"
- b *do_something* = 01000000
- In Bitwise.java we have this: int[] bitmasks = {1, 2, 4, 8, 16, 32, 64, 128};
- You should think of a way to use it.
- THINK: What is the binary representation of 64?
- 64 in binary is:
  (0*2^7)+(1*2^6)+(0*2^5)+(0*2^4)+(0*2^3)…
  which is: 01000000
- b *do_something* = 01000000 ????
- b | bitmasks[6] = 01000000
- Because: 00000000
  | 01000000
  = 01000000

- Use this kind of logic to implement the functions in Bitwise.java

Testing

- When you are done implementing the 7 methods in Bitwise.java test them with TestBitwise.java

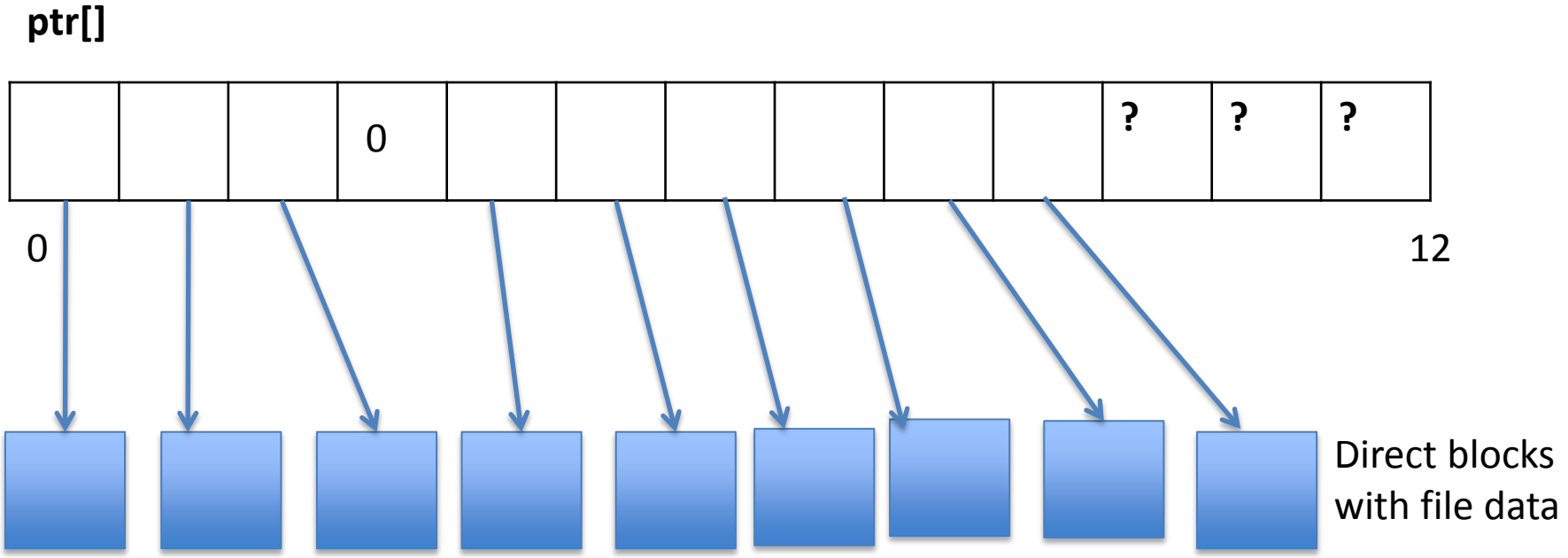
inodes

- Each file in the system is described by an index node -> inode.
- Inode has info about the file: owner, type of file, size etc.
- The one we really care about:

  int[] ptr = new int[13];

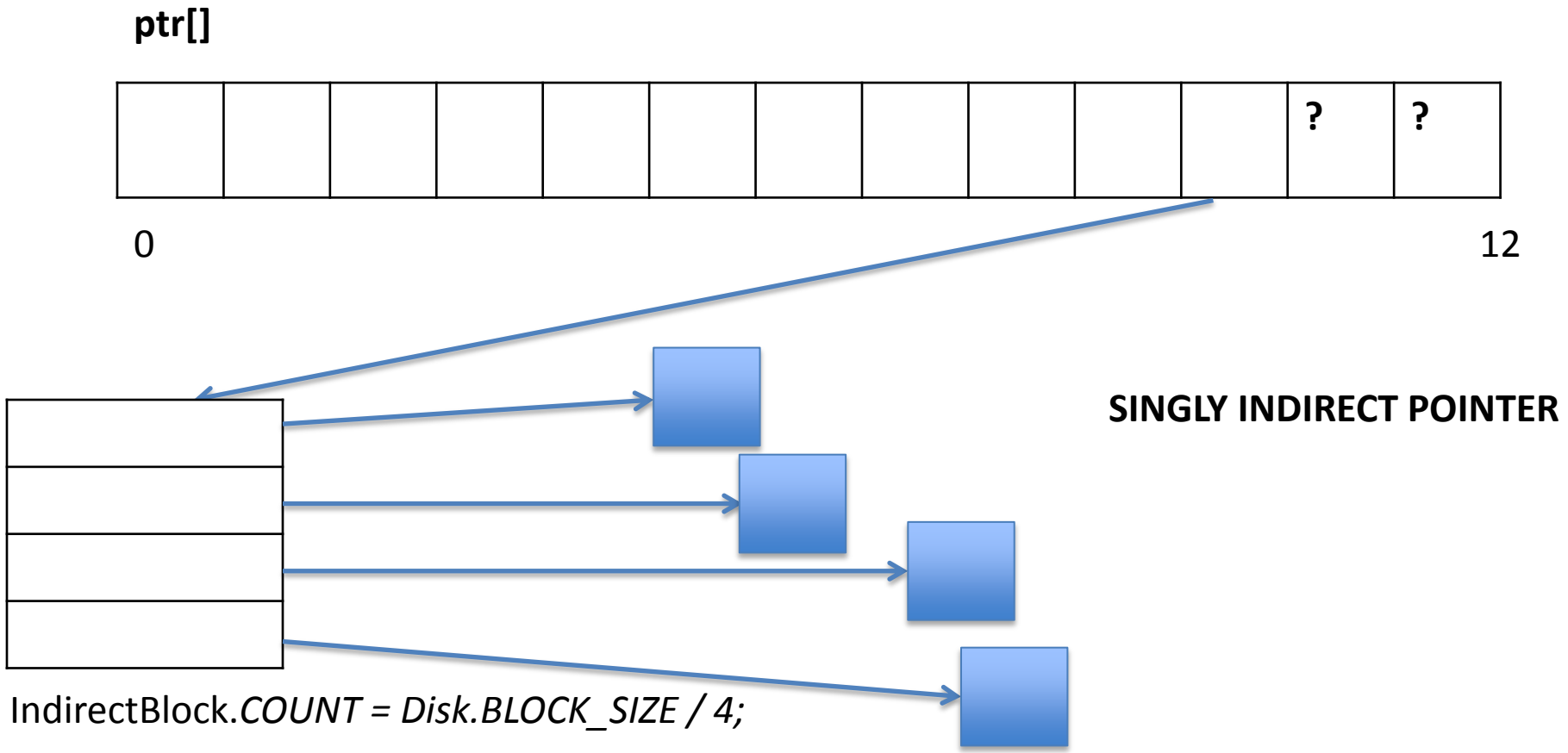
- Pointer fields point directly/indirectly to the data blocks the file occupies.
  - A direct block contains file data.
  - An indirect block contains pointers that point to direct blocks or other indirect blocks.
  - They are both disk blocks so they have the same size.

Direct Blocks



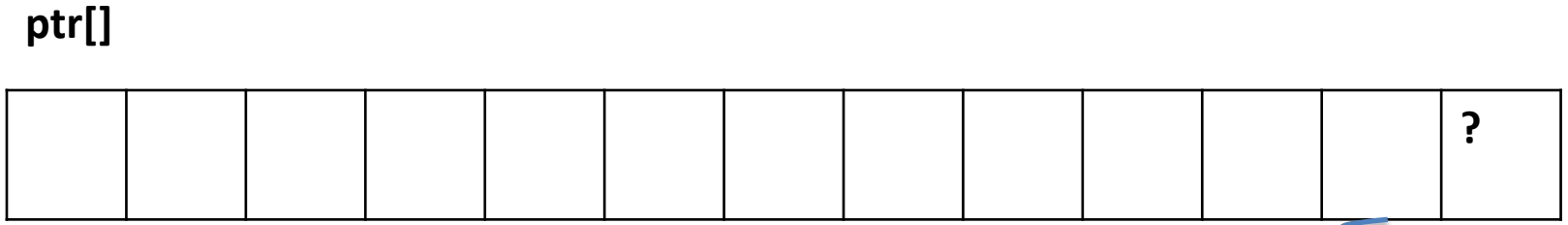
- The first 10 pointers in ptr[] point to the first 10 **direct** blocks of the file.
- Ptr[3] = 0 is a null pointer that indicates a **hole** in the file.

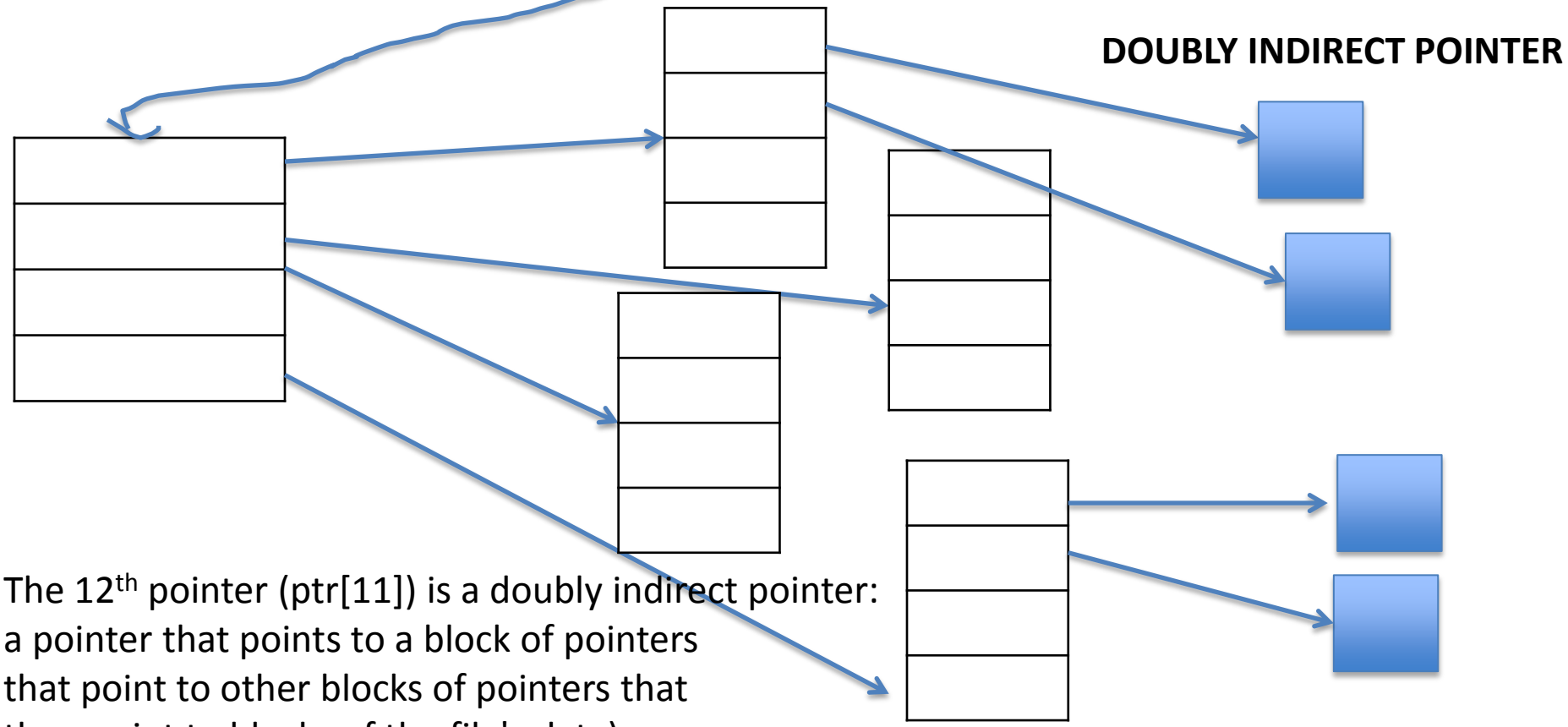
Indirect Blocks



- The 11nth pointer at position ptr[10] points to an indirect block.
- It points to a block of pointers that they point directly to the data blocks of the file.

Indirect Blocks





The 12th pointer (ptr[11]) is a doubly indirect pointer:
a pointer that points to a block of pointers
that point to other blocks of pointers that
then point to blocks of the file's data)

Indirect Blocks

- You can imagine what ptr[12] holds…
- A triply indirect pointer: a pointer that points to a block of pointers that point to other blocks of pointers that point to other blocks of pointers that then point to data blocks containing the file's data.

Indirect Blocks

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- A triply indirect pointer: a pointer that points

What is the maximum file size we can have in blocks?
Assume indirect_block.count is 4.

containing the file's data.

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ANSWER:
10 + 4 + 4*4 + 4*4*4 =
94 BLOCKS!

Your task…

- Implement single-, double-, triple- indirection to support large files.
- Just one function in MyFileSystem.java

```
private DirectBlock getDirectBlock(int fd, MODE mode) { //FIXME!!!
    Inode inode   = fileTable.getInode(fd);
    int seekPtr   = fileTable.getSeekPointer(fd);
    int blockNum  = seekPtr / Disk.BLOCK_SIZE;
    int blockOff  = seekPtr % Disk.BLOCK_SIZE;

    if(blockNum > 9) {
        System.err.println("Large files unsupported");
        System.exit(1);
    }
    boolean fresh = inode.ptr[blockNum] == 0;

    // The blockNum is a logical block number referring to a
    // pointer in the inode.

    if(fresh)
        if(mode == MODE.r)
            return DirectBlock.hole;
        else if((inode.ptr[blockNum] = freeMap.find()) == 0)
            return null;
    return new DirectBlock(disk, inode.ptr[blockNum], blockOff, fresh);

}
```

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file descriptor of an open file

MODE.r for read
MODE.w for write

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return a DirectBlock object representing the direct block given the current seek position in the open file identified by fd.

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logical block number referring to a data block.

offset within that block that the seek pointer is at.

points somewhere inside the open file.

Example with Indirection

- Let's assume you want to read a direct block. Here is some info:
  - SeekPointer = 192
  - Disk.Block_Size = 16
  - IndirectBlock.COUNT = Disk.Block_size/4 = 4
- BlockNum ?

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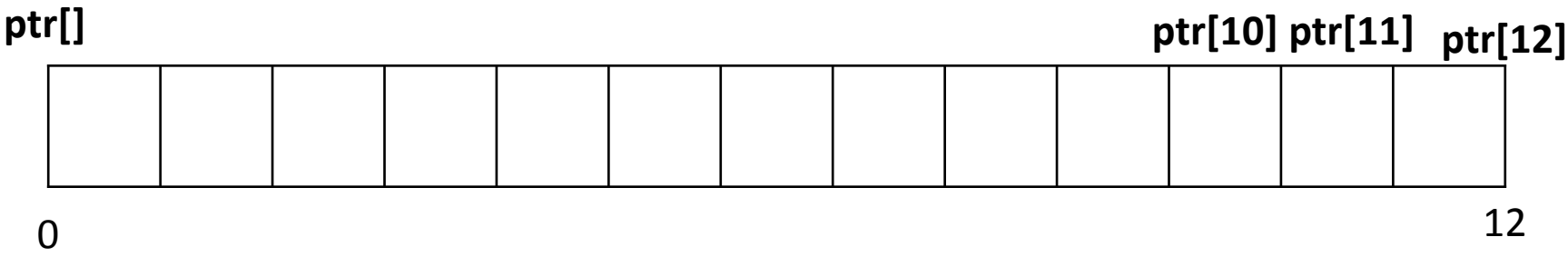
- BlockOff ?
- = 192%16= 0
- BlockNum is 12 (12>10) so we know there is indirection involved. What level though?



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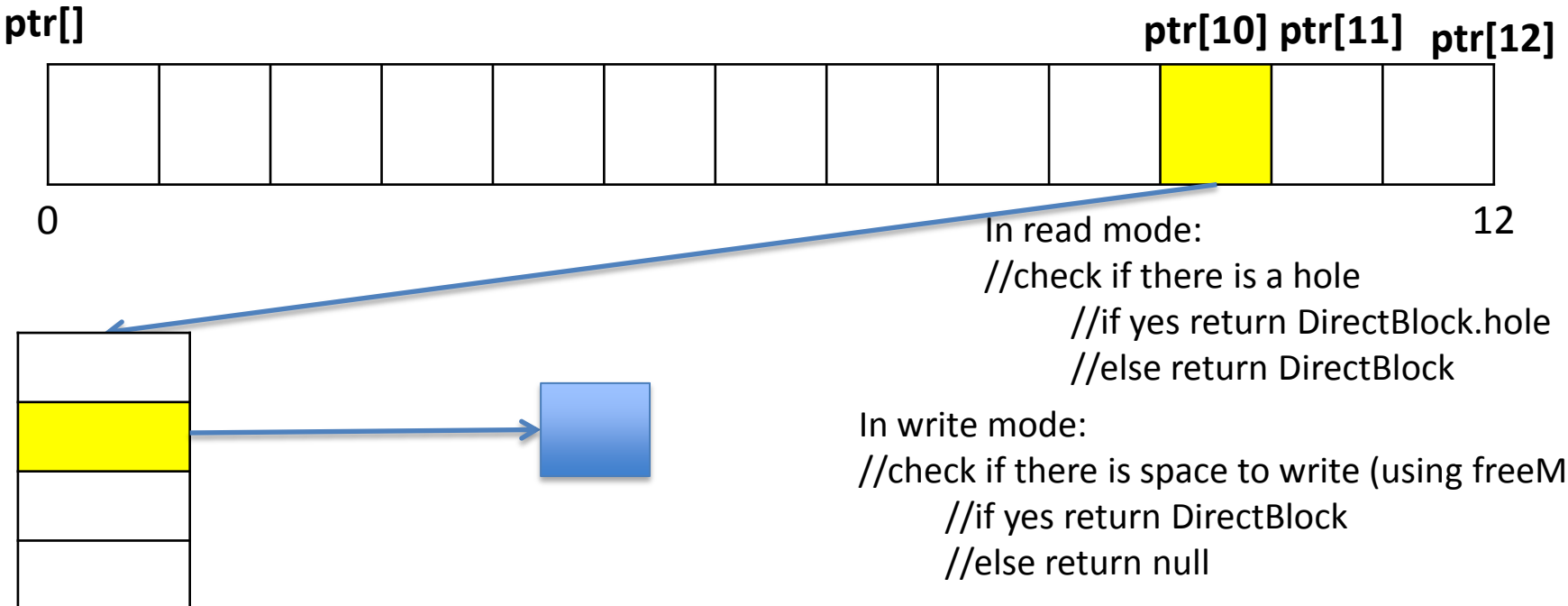
- Single Indirection level.
- To answer why, we should think what is the max BlockNum we can have in the single indirection level?
- 14



Testing

- When you are done implementing indirection in MyFileSystem.java test it with TestMyFileSystem.java.
- Different tests for each indirection level so you can individually test your implementation for all indirection levels.

Questions?