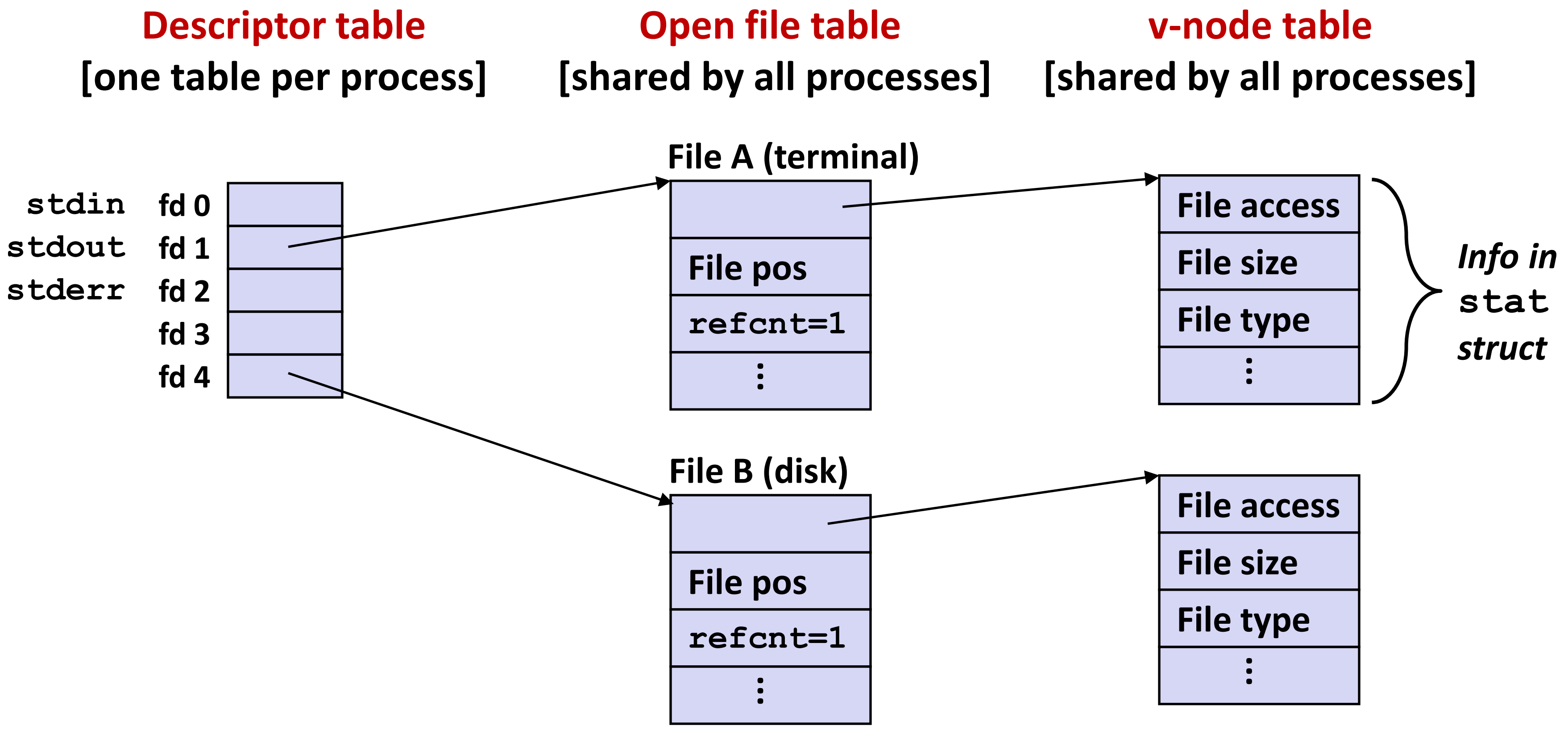
System-Level I/O: *Sharing & redirection*

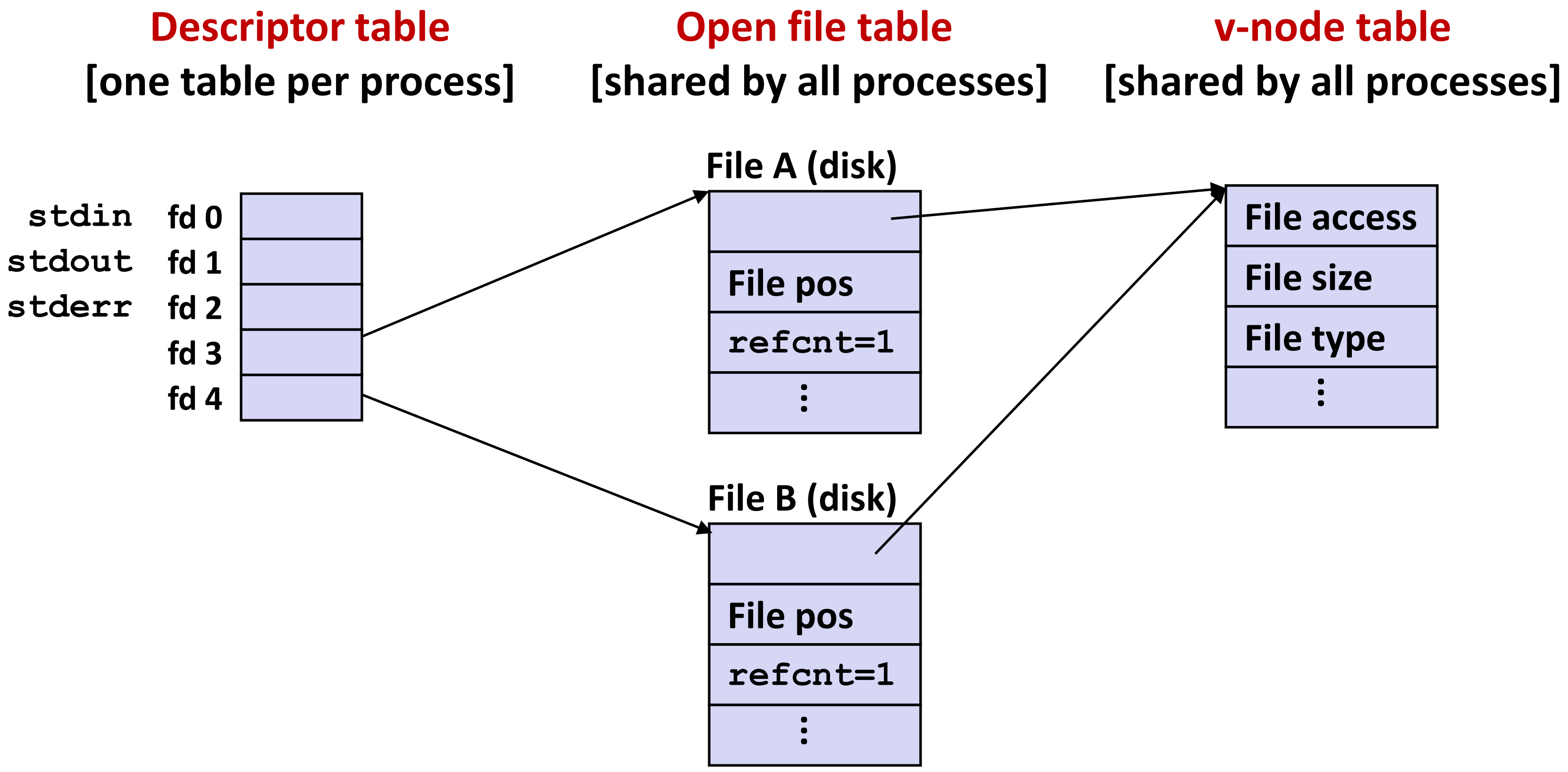
How the Unix Kernel Represents Open Files

- **Two descriptors referencing two distinct open files. Descriptor 1 (stdout) points to terminal, and descriptor 4 points to open disk file**



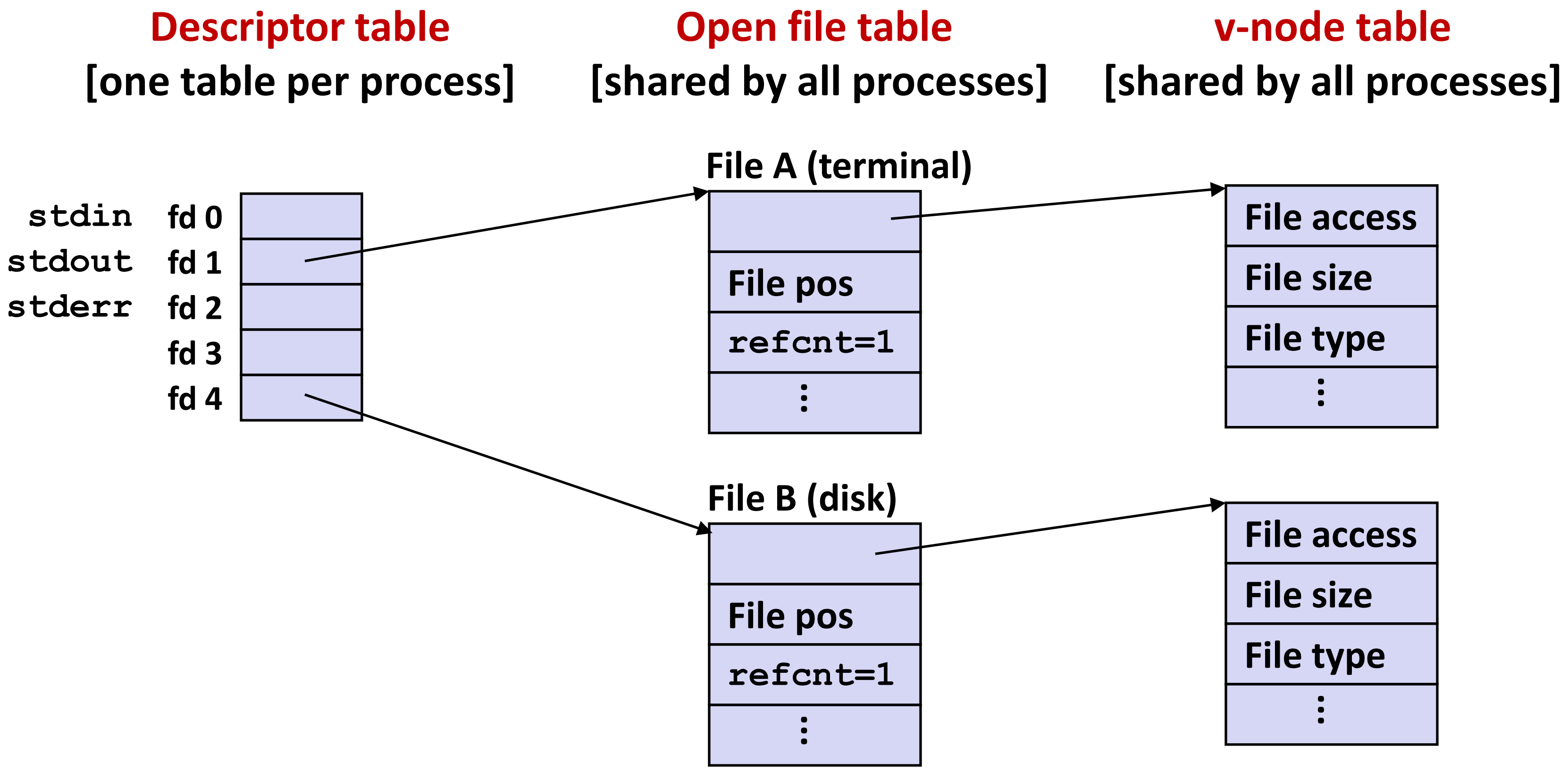
File Sharing

- **Two distinct descriptors sharing the same disk file through two distinct open file table entries**
  - E.g., Calling **`open`** twice with the same **`filename`** argument



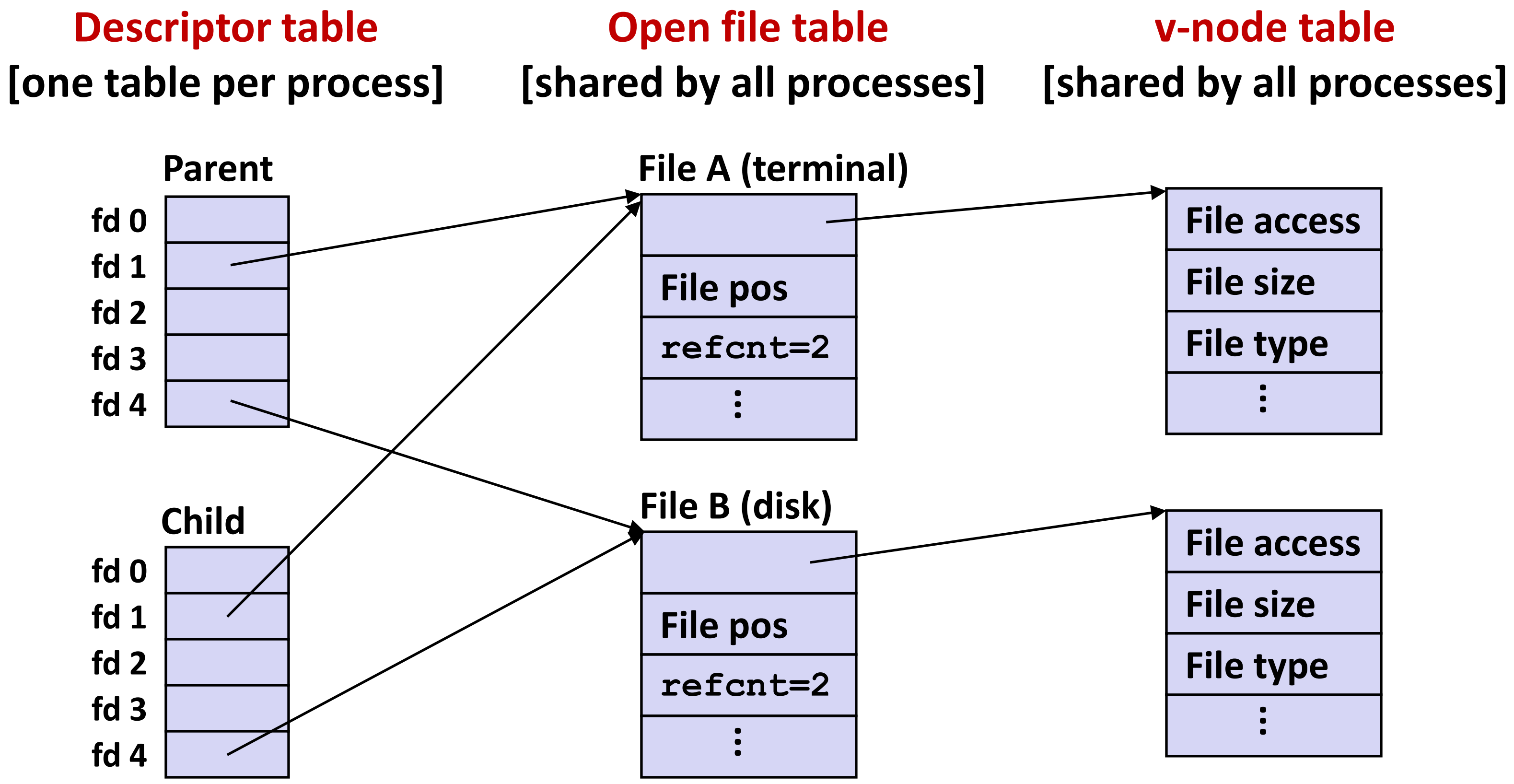
How Processes Share Files: `fork`

- A child process inherits its parent's open files
  - Note: situation unchanged by **`exec`** functions (use **`fcntl`** to change)
- *Before* **`fork`** call:



How Processes Share Files: `fork`

- A child process inherits its parent's open files
- *After* `fork`:
  - Child's table same as parent's, and +1 to each refcnt



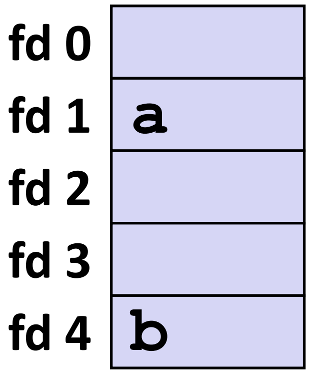
I/O Redirection

- **Question: How does a shell implement I/O redirection?**

```
$ ls > foo.txt
```

- **Answer: By calling the `dup2(oldfd, newfd)` function**
  - Copies (per-process) descriptor table entry **`oldfd`** to entry **`newfd`**

Descriptor table
before **`dup2(4,1)`**



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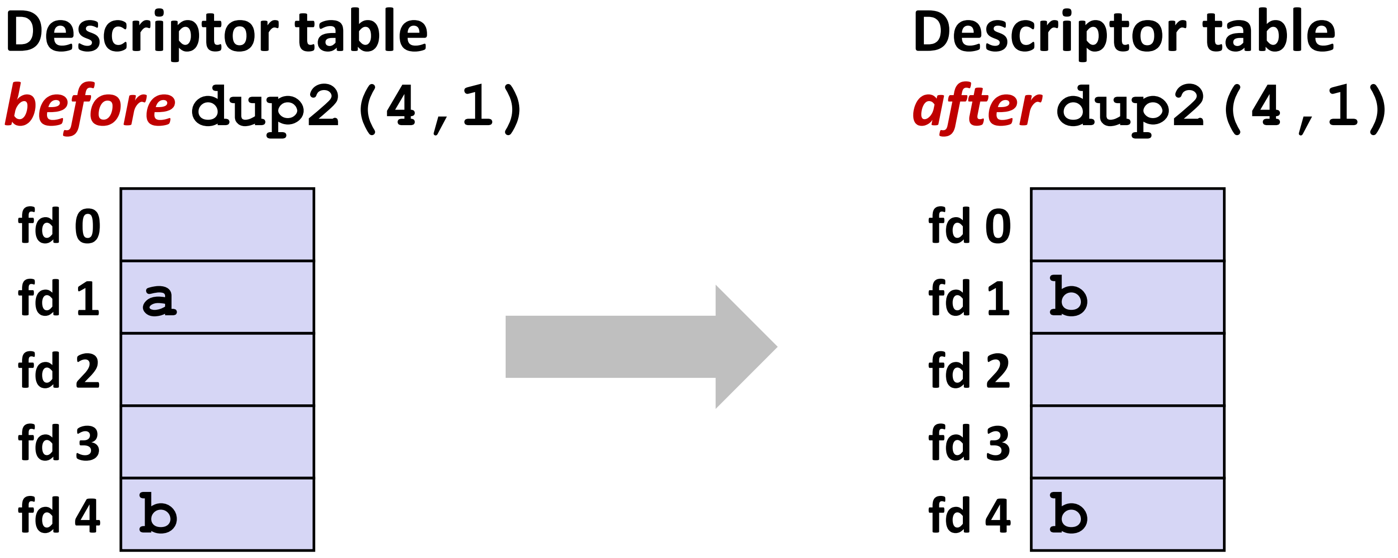
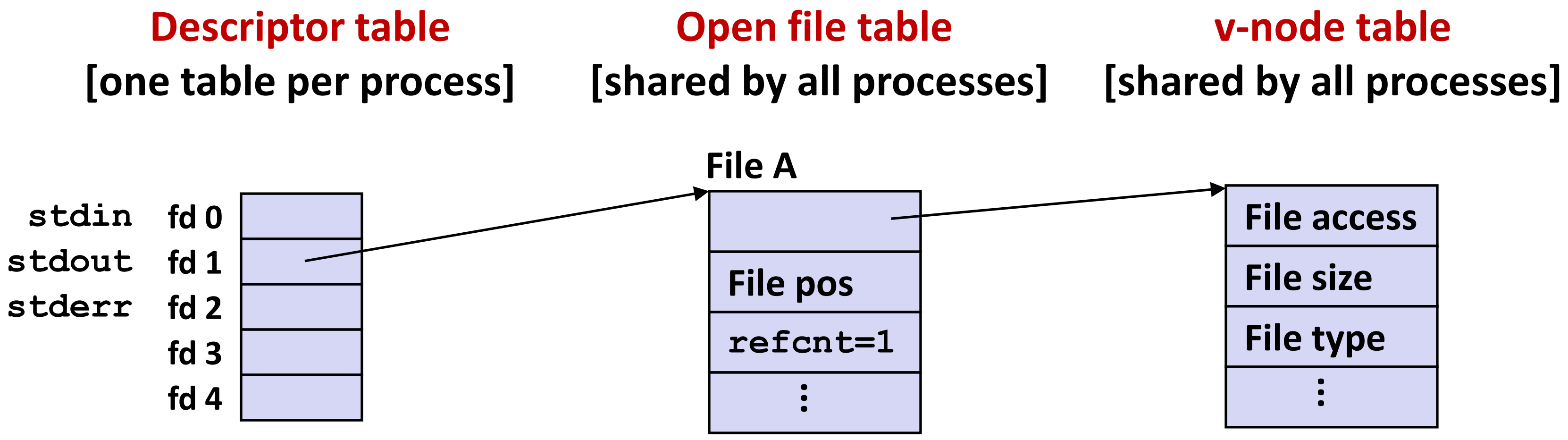


I/O Redirection Example

- **Step #1: open file to which stdout should be redirected**
  - Happens in child executing shell code, before **`exec`**



I/O Redirection Example

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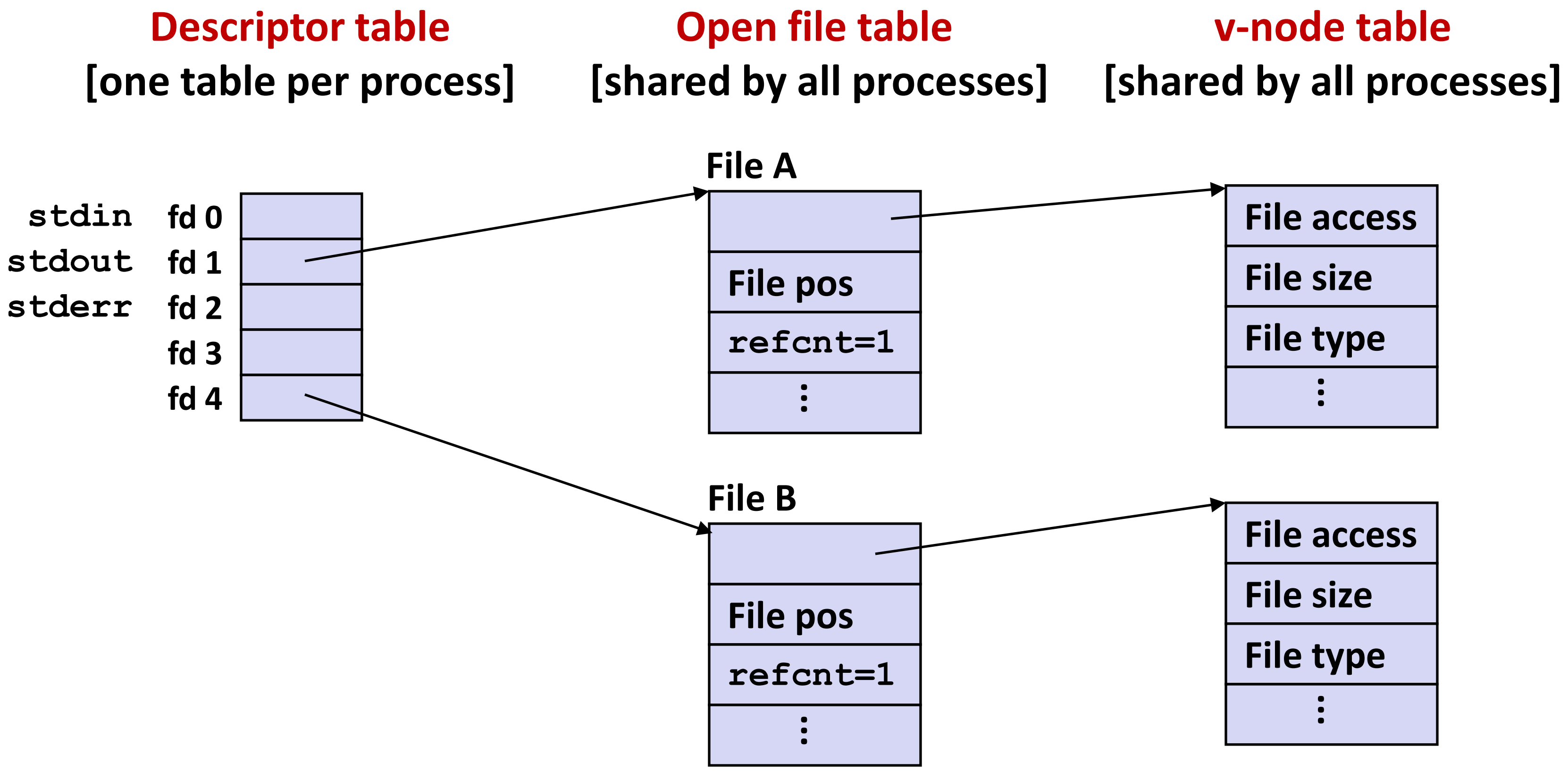
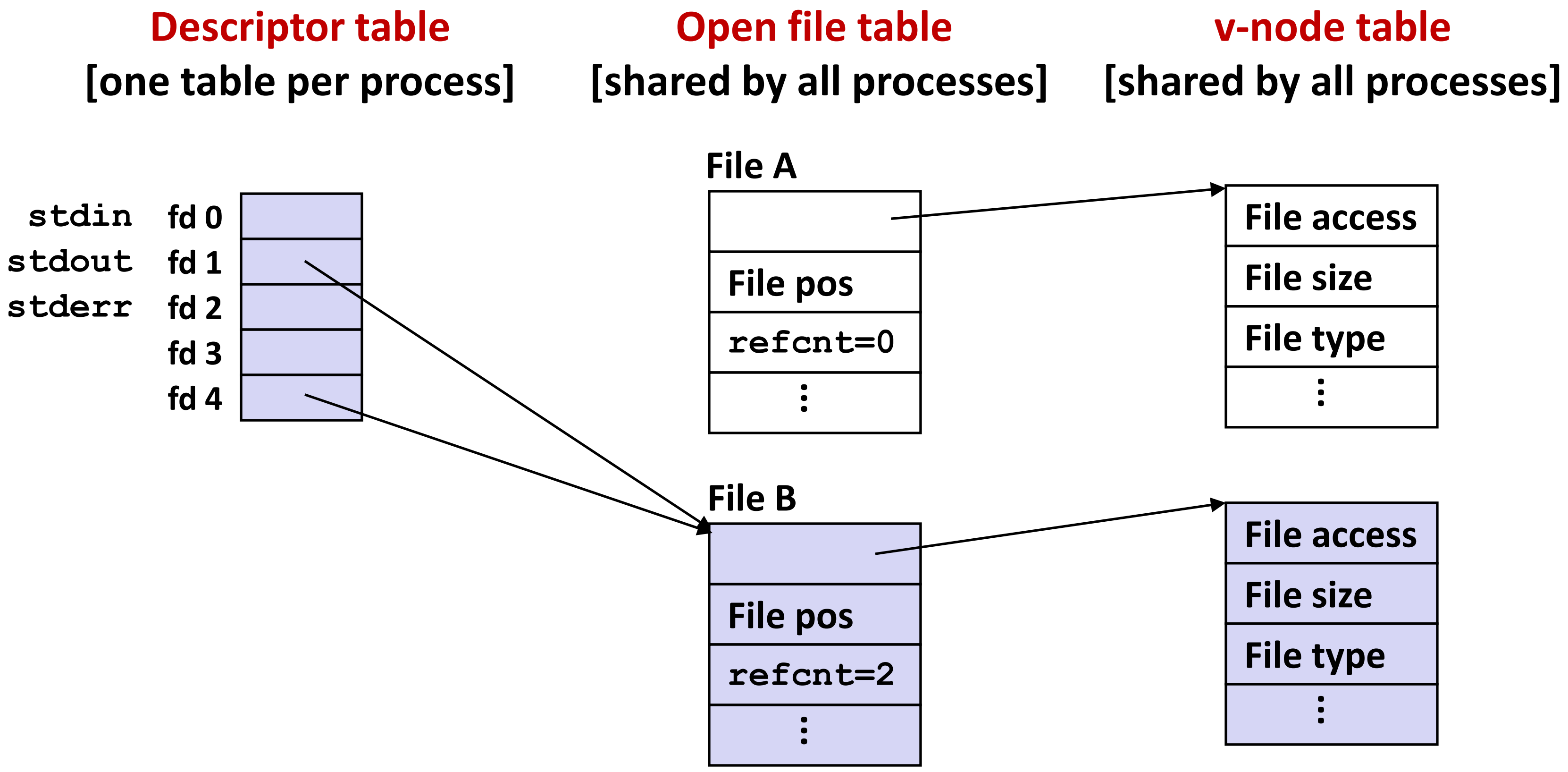
  - Happens in child executing shell code, before **`exec`**



I/O Redirection Example (cont.)

- **Step #2: call `dup2(4,1)`**
  - cause fd=1 (stdout) to refer to disk file pointed at by fd=4


Descriptor table
[one table per process]
Open file table
[shared by all processes]
v-node table
[shared by all processes]
stdin
fd 0
stdout
fd 1
stderr
fd 2
fd 3
fd 4
File A
File pos
refcnt=0
File B
File pos
refcnt=2
File access
File size
File type
File access
File size
File type