

L16: Atomicity

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Bank account transfer

xfer(bank, a, b, amt):

bank[a] = bank[a] - amt

bank[b] = bank[b] + amt

Bank account transfer

xfer(bank, a, b, 50):

xfer(bank, a, b, amt):

bank[a] = bank[a] - amt

bank[b] = bank[b] + amt

← *a=100, b=100*

← *a=50, b=100*

← *a=50, b=150*

Bank account transfer

```
xfer(bank, a, b, amt):
```

```
    bank[a] = bank[a] - amt
```

```
    bank[b] = bank[b] + amt
```

```
audit(bank):
```

```
    sum = 0
```

```
    for acct in bank:
```

```
        sum = sum + bank[acct]
```

```
    return sum
```

Bank account transfer

audit(bank):

xfer(bank, a, b, amt):

bank[a] = bank[a] - amt

bank[b] = bank[b] + amt

← *sum=200*

← *sum=150*

← *sum=200*

audit(bank):

sum = 0

for acct in bank:

sum = sum + bank[acct]

return sum

Eventual goal: transactions all-or-nothing & before-or-after atomicity

xfer(bank, a, b, amt):

begin

bank[a] = bank[a] - amt

bank[b] = bank[b] + amt

commit

audit(bank):

begin

sum = 0

for acct in bank:

 sum = sum + bank[acct]

commit

return sum

Account balances stored in file

```
xfer(bankfile, a, b, amt):  
    f = open(bankfile)  
    abal = f.read(offset: a)  
    bbal = f.read(offset: b)  
    f.write(offset: a, abal - amt)  
    f.write(offset: b, bbal + amt)
```

Shadow copy

```
xfer(bankfile, a, b, amt):  
    copy(bankfile, "newfile")  
    f = open("newfile")  
    abal = f.read(offset: a)  
    bbal = f.read(offset: b)  
    f.write(offset: a, abal - amt)  
    f.write(offset: b, bbal + amt)  
    rename("newfile", bankfile)
```


File system data structures

directory data blocks:

filename "bank" → inode 12

filename "newfile" → inode 13

inode 12:

data blocks: 3, 4, 5

refcount: 1

inode 13:

data blocks: 6, 7, 8

refcount: 1

rename(“newfile”, “bank”)

directory data blocks:

filename “bank” → inode 12

filename “newfile” → inode 13

inode 12:

data blocks: 3, 4, 5

refcount: 1

inode 13:

data blocks: 6, 7, 8

refcount: 1

rename("newfile", "bank")

directory data blocks:

filename "bank" → inode 12

filename "newfile" → inode 13

inode 12:

data blocks: 3, 4, 5

refcount: 1

inode 13:

data blocks: 6, 7, 8

refcount: **2**

rename("newfile", "bank")

directory data blocks:

filename "bank" → inode **13**

filename "newfile" → inode 13

inode 12:

data blocks: 3, 4, 5

refcount: 1

inode 13:

data blocks: 6, 7, 8

refcount: **2**

rename("newfile", "bank")

directory data blocks:

filename "bank" → inode **13**

filename "newfile" → inode 13

inode 12:

data blocks: 3, 4, 5

refcount: **0**

inode 13:

data blocks: 6, 7, 8

refcount: **2**

rename("newfile", "bank")

directory data blocks:

filename "bank" → inode 13

~~filename "newfile" → inode 13~~

inode 12:

data blocks: 3, 4, 5

refcount: 0

inode 13:

data blocks: 6, 7, 8

refcount: 2

rename("newfile", "bank")

directory data blocks:

filename "bank" → inode 13

~~filename "newfile" → inode 13~~

inode 12:

data blocks: 3, 4, 5

refcount: 0

inode 13:

data blocks: 6, 7, 8

refcount: 1

Recovery after crash

```
salvage(disk):  
    for inode in disk.inodes:  
        inode.refcnt =  
            find_all_refs(disk.root_dir, inode)  
  
    if exists("newfile"):  
        unlink("newfile")
```