Lecture 17: Logging

Hari Balakrishnan

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Based on Section 9.3 and some material from Sam Madden

Transaction example

GET(x) – *read value of x from store (database)*
PUT(x,v) – *write v to x in store (database)*

```
xfer(F, T, amt):
        PUT(F, GET(F) – amt)
        PUT(T, GET(T) + amt)

tid = BEGIN_TRANSACTION
        xfer(from, to, amount)
        if read(from) < 0:
                print “Not enough funds”
                ABORT
        else:
                COMMIT      “Do it all”
```

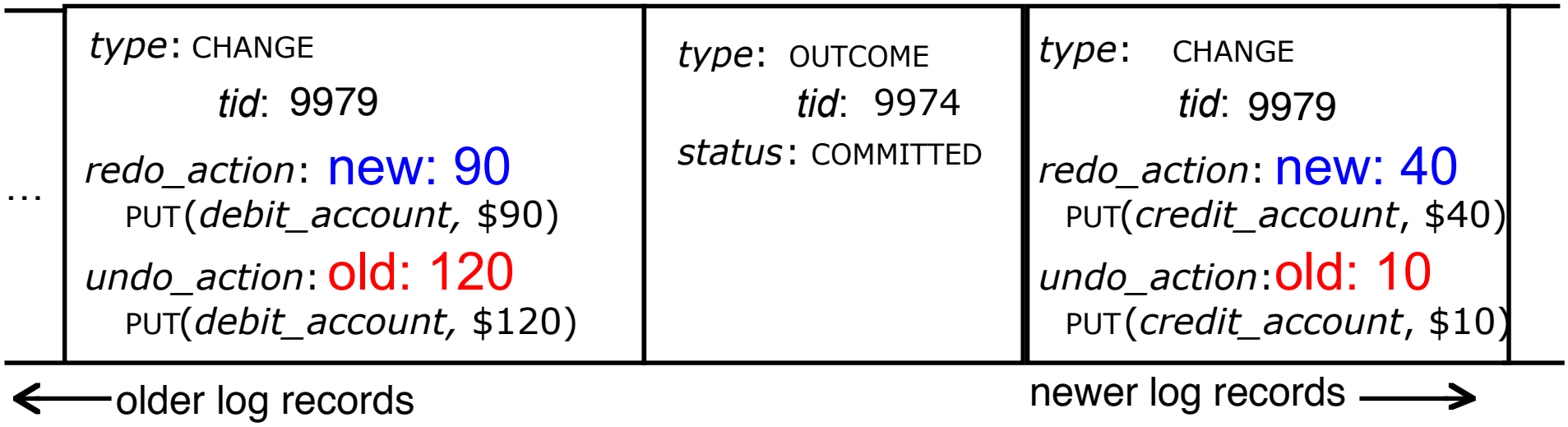
Assumption for today

No concurrent transactions

Focus on crash recovery and ABORT to implement all-or-nothing atomicity and durability for transactions

Log

Append-only data structure: NEVER OVERWRITE OR ERASE!



tid : "transaction identifier", aka "action identifier"

GET (read) with just the log

```
GET(x):    # global log
    commits = { }
      for record r in log[len(log)-1] .. log[0]:
            if (r.status == COMMITTED):
                commits = commits + r.tid
            if (r.type == CHANGE) and
               (r.tid in commits) and
               (r.var == x):
                return r.new_val
```

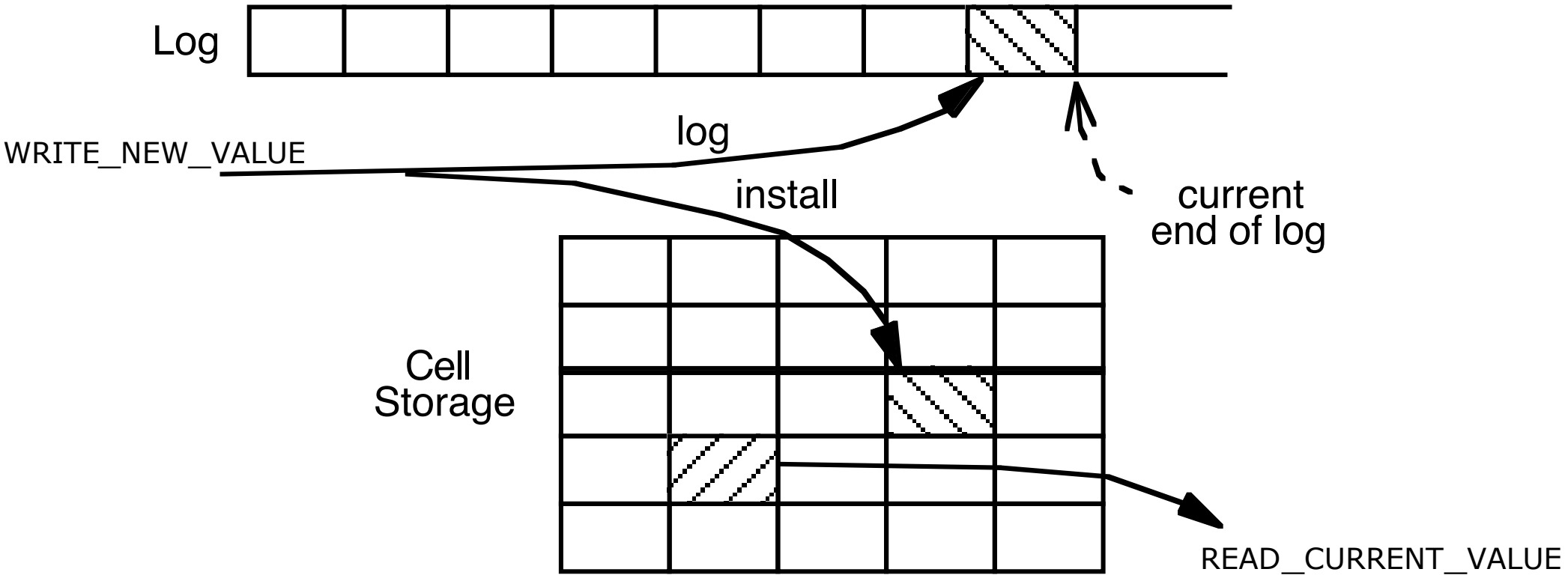
GET (read) your own PUTs (writes)

```
GET(x):
    commits = { }
      for record r in reversed(log): # backward scan
            if (r.status == COMMITTED):
                commits = commits + r.tid
            if (r.type == CHANGE) and
               (r.tid in commits or r.tid=cur_tid) and
               (r.var == x):
                return r.new_val
```

+ Crash recovery is fast! Don't have to do anything
+ PUTs are fast! Just append to log
- GETs are SLOW: have to scan log backwards

Cell Storage + Log

Append-only data structure: NEVER OVERWRITE OR ERASE!



Read / write with cell storage

```
GET(x):
    return cell_read(var)

PUT(x, value):
      old_x = GET(x)
      cell_write(x, value)
      log.append(tid, CHANGE,
                              x, old=old_x, new=value)
```

WRONG!

WRITE-AHEAD LOGGING (WAL)

```
PUT(x, value):   LOG TO STABLE STORAGE FIRST
    log.append(tid, CHANGE,
                        x, old=read(x), new=value)
    cell_write(x, value)
```

1. Volatile cell writes (in-mem DB) Recovering cell storage from log

```
recover(log):
    done = { }
    for record r in reversed(log): # backward scan
        if r.status== COMMITTED:
            winners = winners + r.tid
    for record r in log:  # forward scan
        if r.type == CHANGE and r.tid in winners:
            cell_write(r.var, r.new_val)    # redo
```

2. Non-volatile cell writes: Recovering cell storage from log

```
recover(log):
      winners = { }
      for record r in reversed(log): # backward scan
          if r.status== COMMITTED:
              winners = winners + r.tid
          if r.type == CHANGE and r.tid not in winners:
                  cell_write(r.var, r.old_val)    # undo
```

3. Cached read / write

```
GET(x):
    if x not in cache:
      # may evict another from cache to cell store
      cache[x] = cell_read(x)
    return cache[x]

PUT(x, value):
      log.append(cur_tid, CHANGE,
                          x, old=read(x), new=value)
      # may evict another from cache to cell store
      cache[x] = value
```

3. Recovery for cached database

```
recover(log):
    done = { }
    for record r in reversed(log):  # backward scan
        if r.type == COMMITTED:
            done = done + r.tid
        if r.type == CHANGE and r.tid not in done:
            cell_write(r.var, r.old_val)     # undo

    for record r in log:  # forward scan
        if r.type == CHANGE and r.tid in done:
            cell_write(r.var, r.new_val)   # redo
```

Abort (all three cases)

```
abort():  # ABORT current transaction, cur_tid
    for record r in reversed(log)
        if (r.tid == cur_tid)
            if r.type == CHANGE:
                PUT(r.var, r.old_val)  # undo
            if r.type == BEGIN
                break
    log.append(cur_tid, ABORTED)  # optional
    # to avoid undo'ing an already-aborted transaction
```