

VanillaCore Walkthrough

Part 4

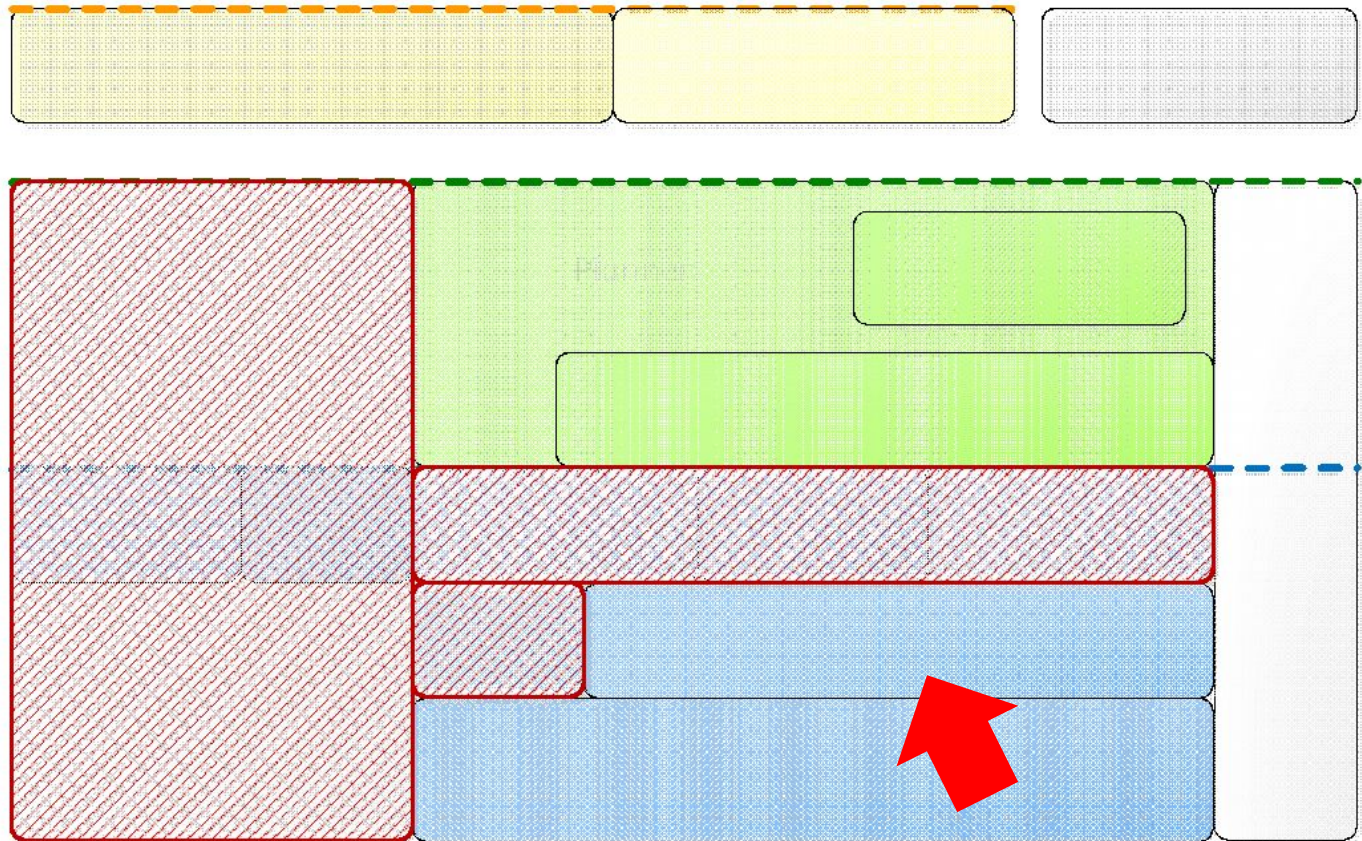
Introduction to Databases

DataLab

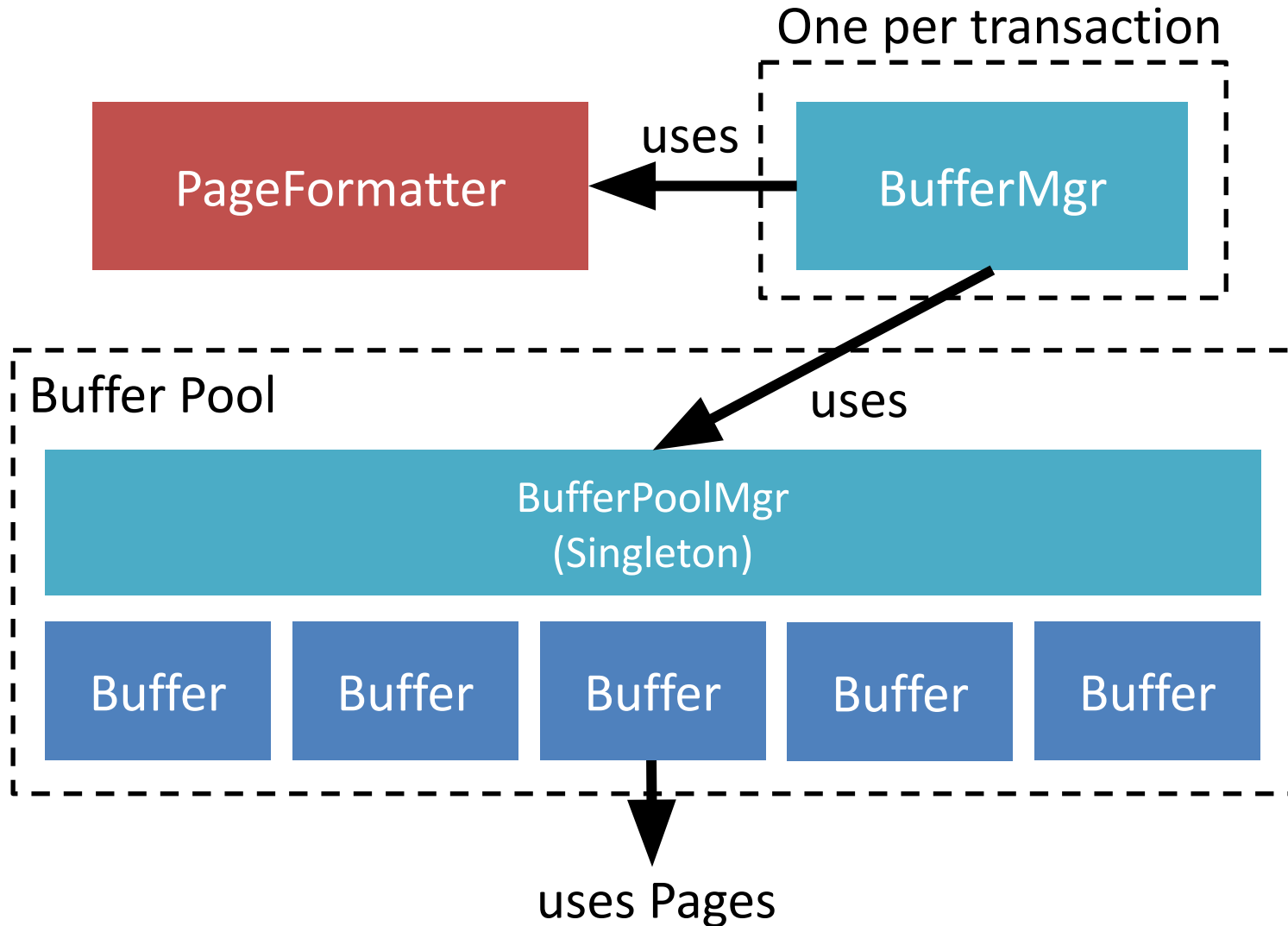
CS, NTHU

Today's Focus

Navigation icons



buffer Package



Functionality

- Main Components
 - Buffer: a memory space for caching a block
 - BufferPoolMgr: manages the buffer pool
 - BufferMgr: provides the access to buffers and manages the pinned buffers for each transaction
 - A transaction waits here if it could not pin any buffer.
 - PageFormatter: formats a fresh block

Functionality

- **Main Components**

- **Buffer**: a memory space for caching a block
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Buffer

- Wraps a page and stores
 - ID of the holding block
 - Pin count
 - Modified information
 - Log information
- ***Supports WAL***
 - `setVal()` requires an LSN
 - Must be preceded by `LogMgr.append()`
 - `flush()` calls `LogMgr.flush(maxLsn)`

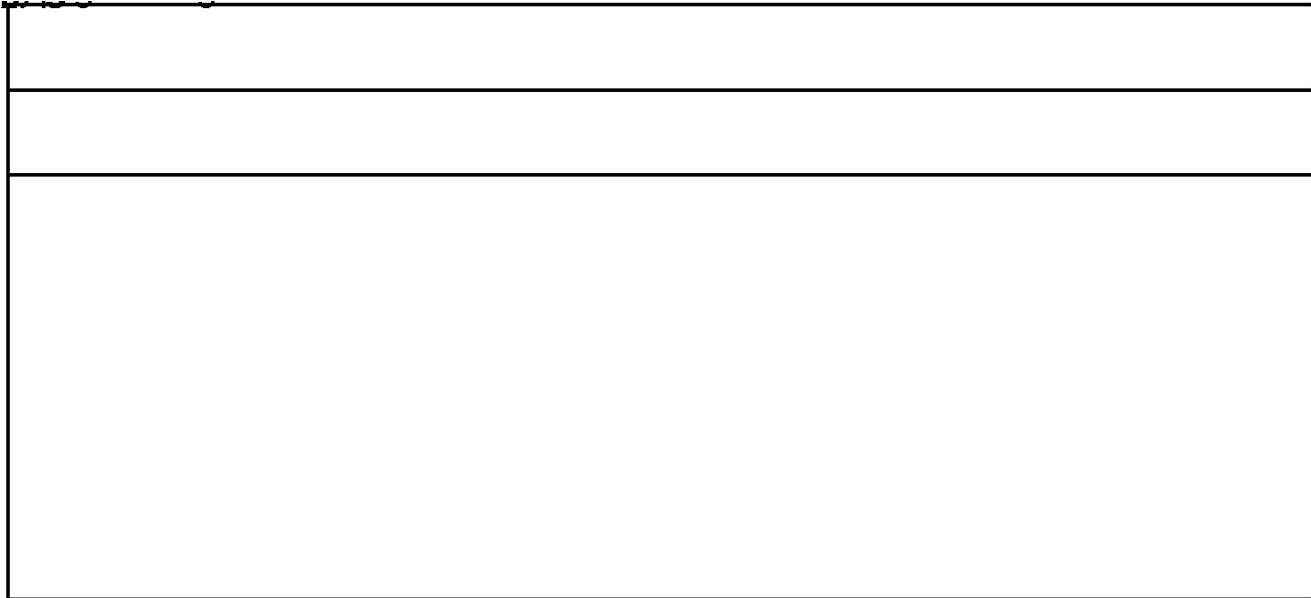
Buffer
<pre>~ Buffer() <<synchronized>> + getVal(offset : int, type : Type) : Constant <<synchronized>> + setVal(offset : int, val : Constant, txnum : long, lsn : long) <<synchronized>> + block() : BlockId <<synchronized>> ~ flush() <<synchronized>> ~ pin() <<synchronized>> ~ unpin() <<synchronized>> ~ isPinned() : boolean <<synchronized>> ~ isModifiedBy(txNum : long) : boolean <<synchronized>> ~ assignToBlock(b : BlockId) <<synchronized>> ~ assignToNew(filename : String, fmtr : PageFormatter)</pre>

Functionality

- **Main Components**

- `Buffer`: a memory space for caching a block
- `BufferPoolMgr`: **manages the buffer pool**
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BufferPoolMgr



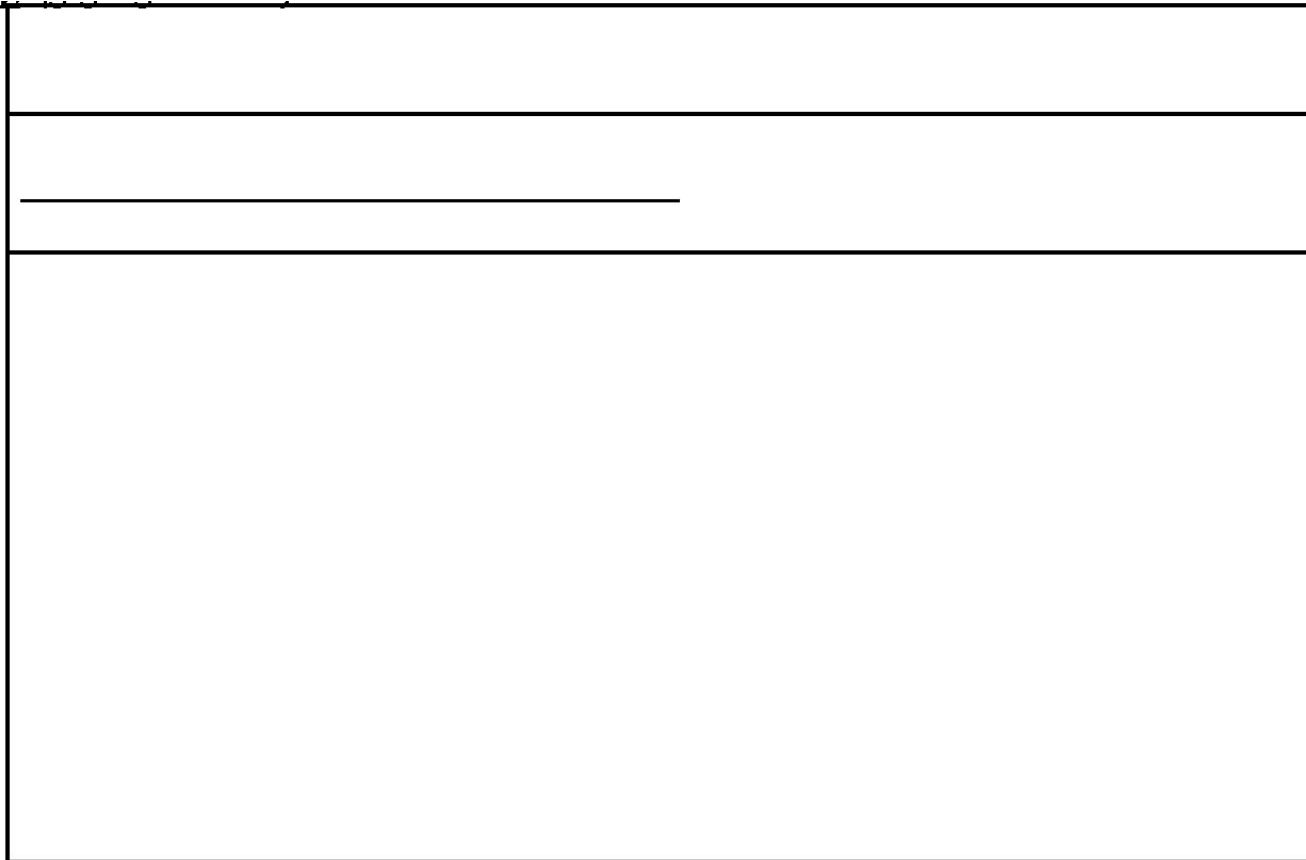
BufferPoolMgr

- Singleton
- Finds a hit for a `pin()`
- Implements the ***clock*** replacement strategy
- The `pin()` ***returns null immediately*** if there's no candidate buffer
 - Then, the `BufferMgr` make the calling thread waiting and retrying later

Functionality

- Main Components
 - `Buffer`: a memory space for caching a block
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BufferMgr



BufferMgr

- Created when constructing a transaction
- A `BufferMgr` manages the pinned buffers and the pinning counts of a transaction
- `BufferMgr.pin()` makes the calling thread to wait if there's no candidate buffer for replacement

Java `wait()` and `notifyAll()` Methods

- In Java, every object has a waiting list
 - `obj.wait(timeout)` puts the caller thread into the waiting list of `obj`
- The thread will be removed from the list and ready for execution in two conditions:
 - Another thread call `obj.notifyAll()`
 - Timeout elapsed

Java `wait()` and `notifyAll()` Methods

- If...
 1. `obj.wait()` is surrounded by a synchronized block, and
 2. there are multiple threads in `obj`'s waiting list,
- Then when `notifyAll()` is called, **all** waiting threads will compete on the lock to enter the synchronized block
 - **No** FIFO guarantee which thread will be notified first, and which will acquire the lock first
 - Only one thread wins the lock, others **blocked** until the winner releases the lock

BufferMgr

- `pin()`: if `BufferPoolMgr` returns null, put the current thread into `BufferPoolMgr`'s waiting list

```
buff = bufferPool.pin(blk);
while (buff == null && !waitingTooLong(timestamp)) {
    bufferPool.wait(MAX_TIME);
    buff = bufferPool.pin(blk);
}
```

- `unpin(buff)`: notify all threads in `BufferPoolMgr`'s waiting list
 - Only one thread will pin successfully due to the synchronization

BufferMgr vs. BufferPoolMgr

- Each transaction has its own BufferMgr, but there is only one BufferPoolMgr
- Responsibility
 - BufferPoolMgr manages the buffer pool
 - BufferMgr handles waiting for pinning and manages pinned buffers for each transaction


```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

Synchronize on the buffer pool (singleton)

```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

Find the given block from the pinned buffers of this transaction

```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

Pins the requested block

Add the buffer to the pinned list of this transaction

```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

If there was not any available buffer, make the thread waiting

The thread in the head of the list can pin

Wake up other thread again

```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

**Waiting too long? There might be deadlock.
Re-pin all blocks**

```

public Buffer pin(BlockId blk) {
    synchronized (bufferPool) {
        PinnedBuffer pinnedBuff = pinnedBuffers.get(blk);
        if (pinnedBuff != null) {
            pinnedBuff.pinnedCount++;
            return pinnedBuff.buffer;
        }
        if (pinnedBuffers.size() == BUFFER_POOL_SIZE)
            throw new BufferAbortException();
        try {
            Buffer buff;
            long timestamp = System.currentTimeMillis();
            buff = bufferPool.pin(blk);
            if (buff == null) {
                waitingThreads.add(Thread.currentThread());
                while (buff == null && !waitingTooLong(timestamp)) {
                    bufferPool.wait(MAX_TIME);
                    if (waitingThreads.get(0).equals(Thread.currentThread()))
                        buff = bufferPool.pin(blk);
                }
                waitingThreads.remove(Thread.currentThread());
                bufferPool.notifyAll();
            }
            if (buff == null) {
                repin();
                buff = pin(blk);
            } else {
                pinnedBuffers.put(buff.block(), new PinnedBuffer(buff));
            }
            return buff;
        } catch (InterruptedException e) {
            throw new BufferAbortException();
        }
    }
}

```

Self-deadlock: throw exception

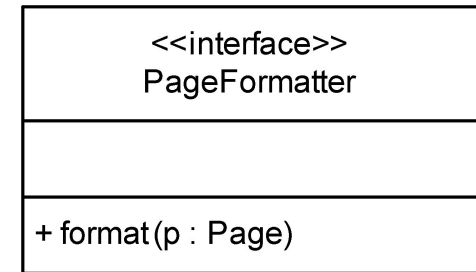
Functionality

- **Main Components**

- `Buffer`: a memory space for caching a block
- `BufferPoolMgr`: manages the buffer pool
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 - A transaction waits here if it could not pin any buffer.
- `PageFormatter`: **formats a fresh block**

PageFormatter

- The `pinNew(fmtr)` method of `BufferMgr` appends a new block to a file
- `PageFormatter` initializes the block
 - To be extended in packages (`storage.record` and `storage.index.btree`) where the semantics of records are defined



```
class ZeroIntFormatter implements PageFormatter {
    public void format(Page p) {
        Constant zero = new IntegerConstant(0);
        int recsize = Page.size(zero);
        for (int i = 0; i + recsize <= Page.BLOCK_SIZE; i += recsize)
            p.setVal(i, zero);
    }
}
```