# Improving Postgres' Concurrency

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http://anarazel.de/talks/pgconf-eu-2015-10-30/concurrency.pdf

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# Scalability

*“Scalability is the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged in order to accommodate that growth”*

Wikipedia

# Vertical

Lenovo x3950-x6

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# Horizontal

HP DL60 * 5

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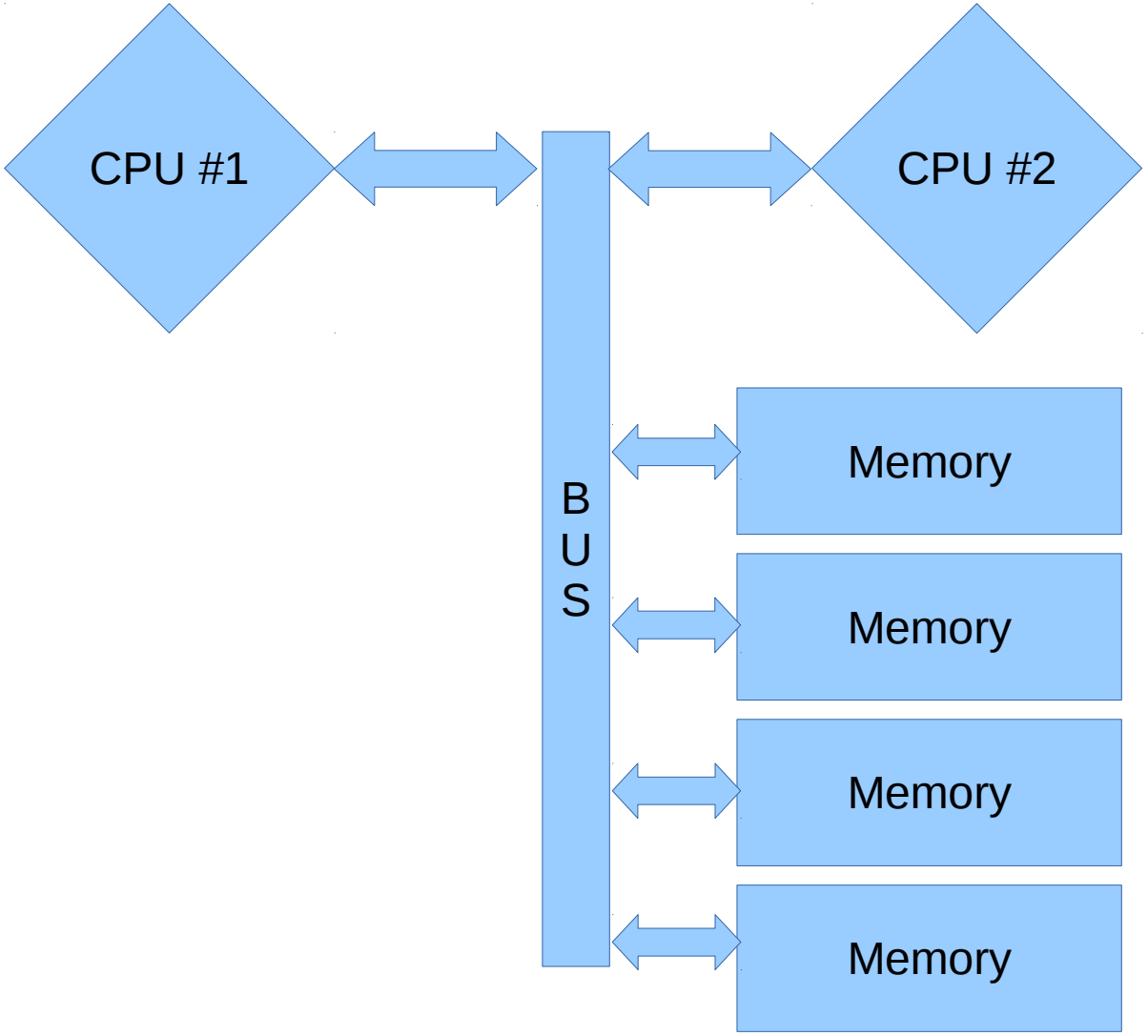
# Vertical Scalability

- Multi-Core CPUs
  - 2005 - 2 cores
  - 2015 – 18 cores
- Often cheaper to develop for
- Lower Latency / Higher Consistency
- Multi-Socket Servers
- NUMA
- Cache Coherency

# Uniform Memory Access

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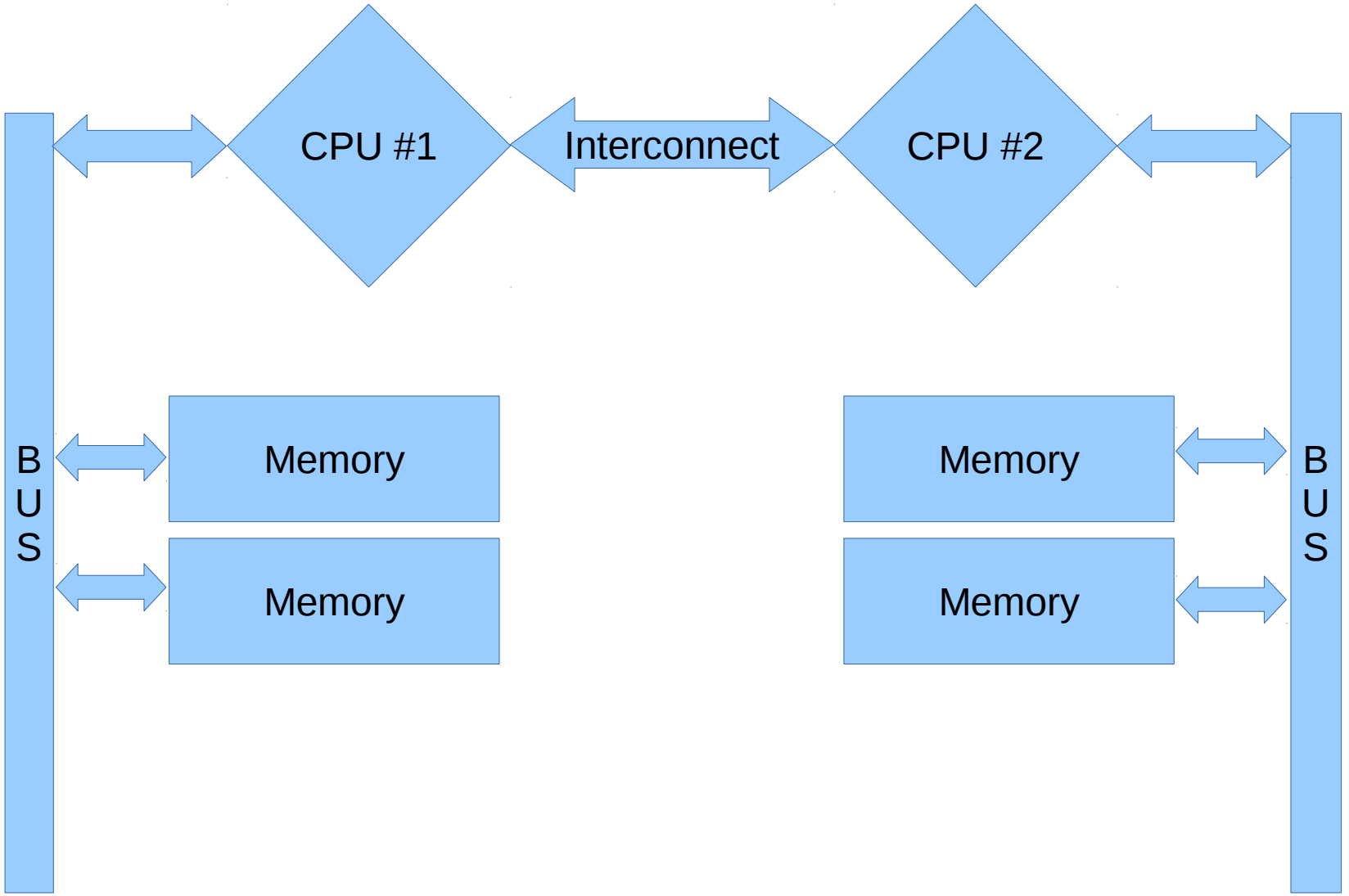
# Non-Uniform Memory Access



# Postgres Locking Primer

- Spinlocks
  - fast (very short locks)
  - exclusive only
  - no queuing (super expensive if locks held too long)
  - no error recovery
  - no deadlock checks
  - fixed number

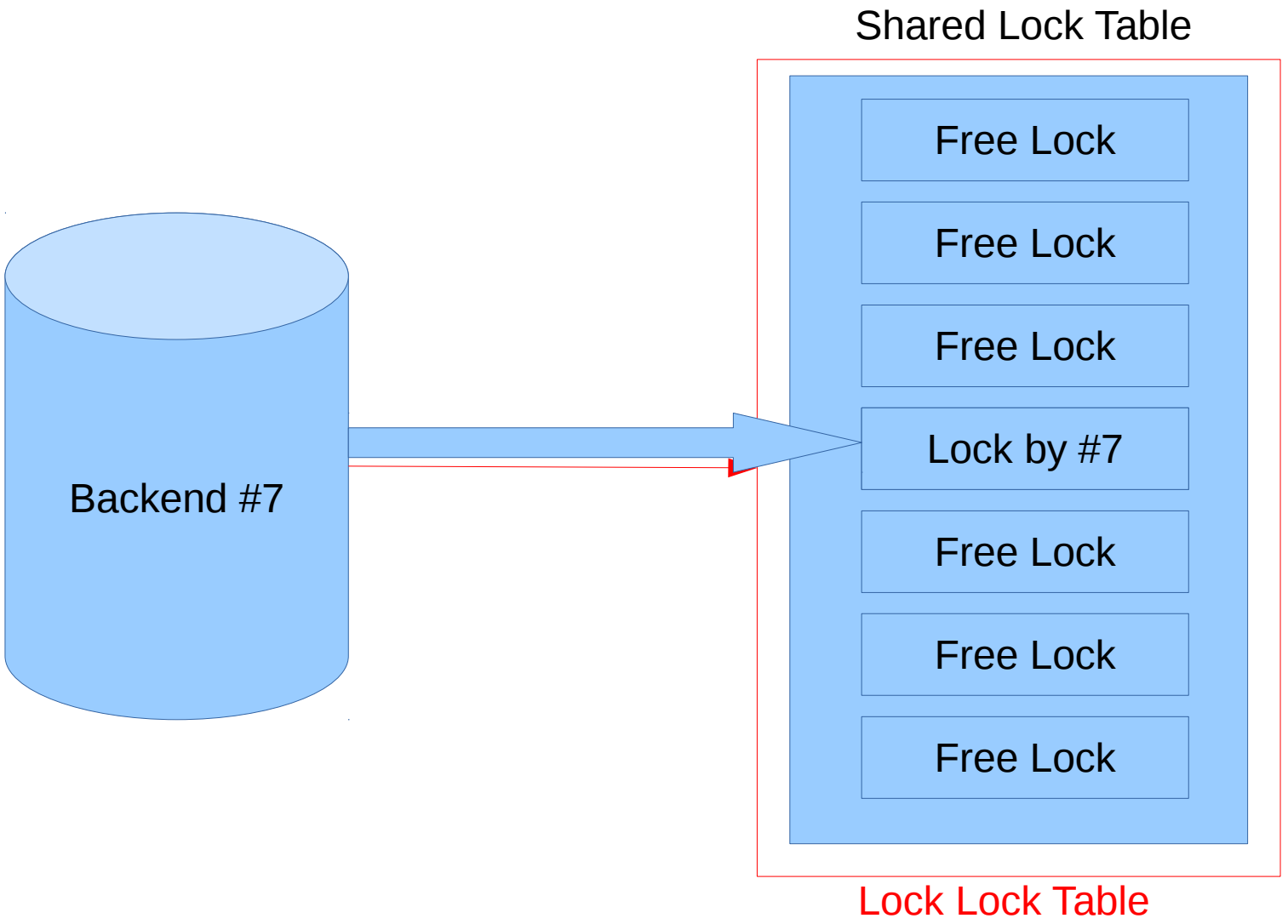
# Postgres Locking Primer

- LWLock
  - fast
  - reader/writer lock
  - error recovery
  - no deadlock checks
  - fixed number
  - uses spinlocks

# Postgres Locking Primer

- Heavyweight Locks
  - complex locking modes
  - error recovery
  - deadlock checks
  - “dynamic” identities
  - uses LWLocks & spinlocks

# Acquiring a Heavyweight Lock

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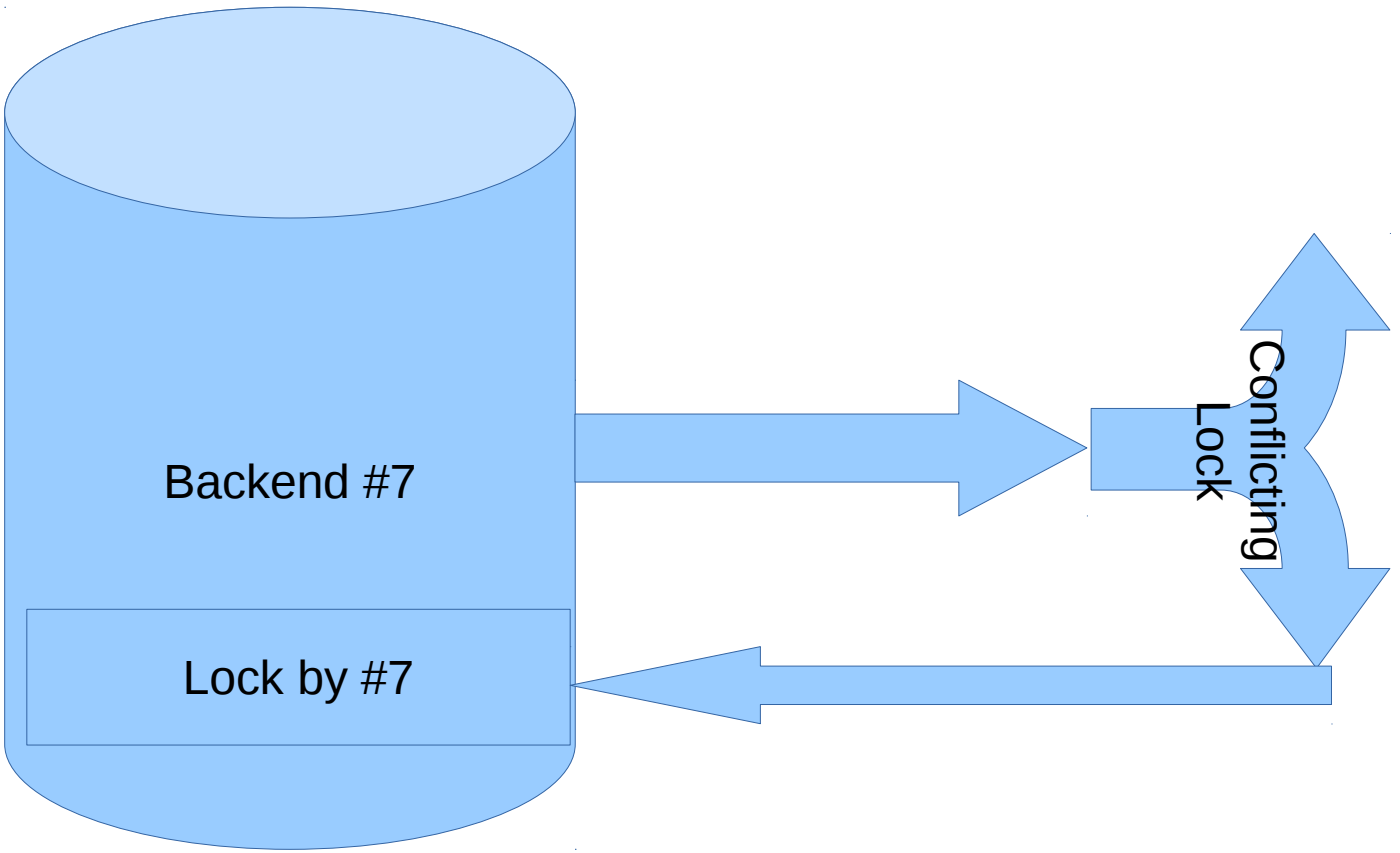
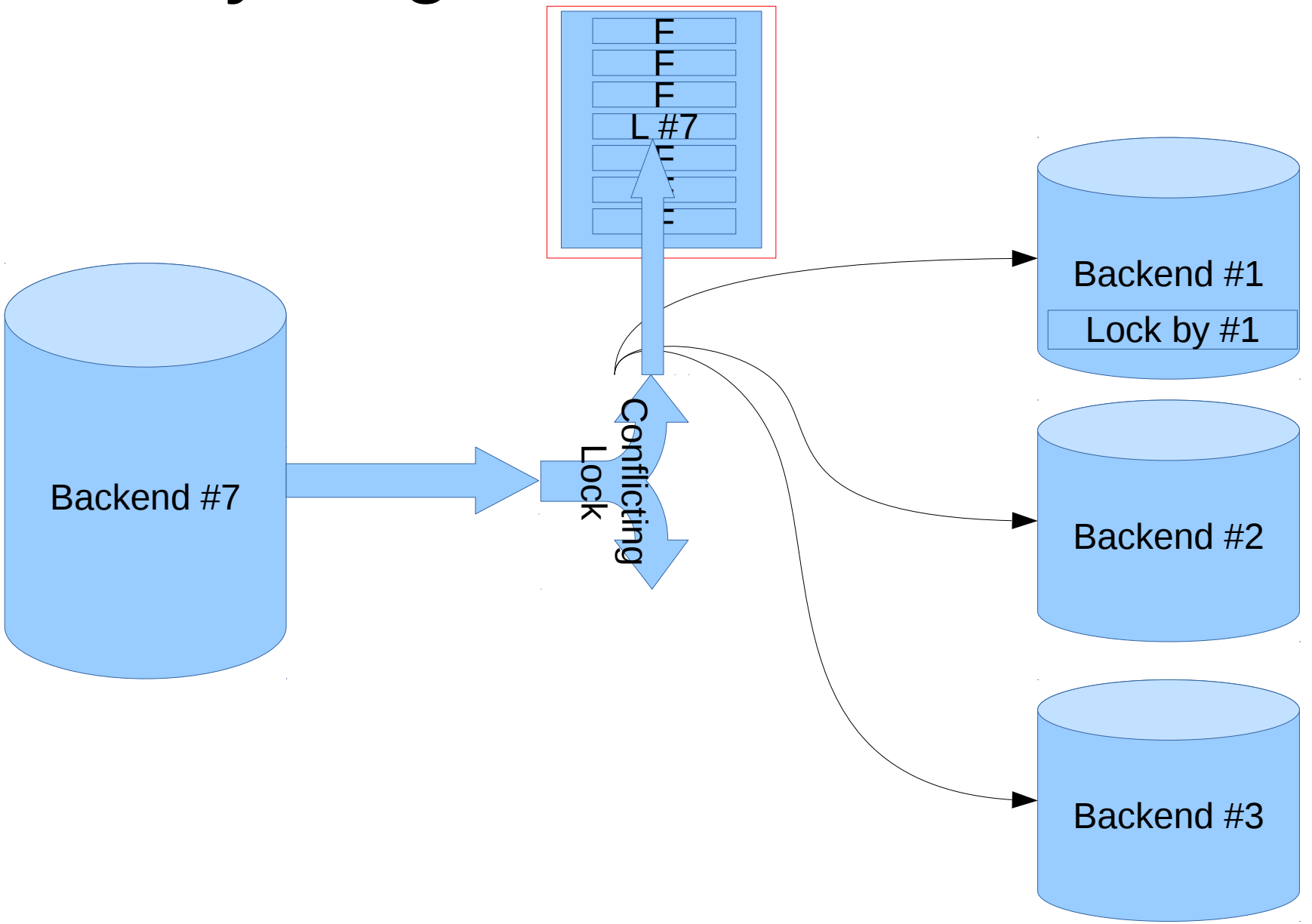
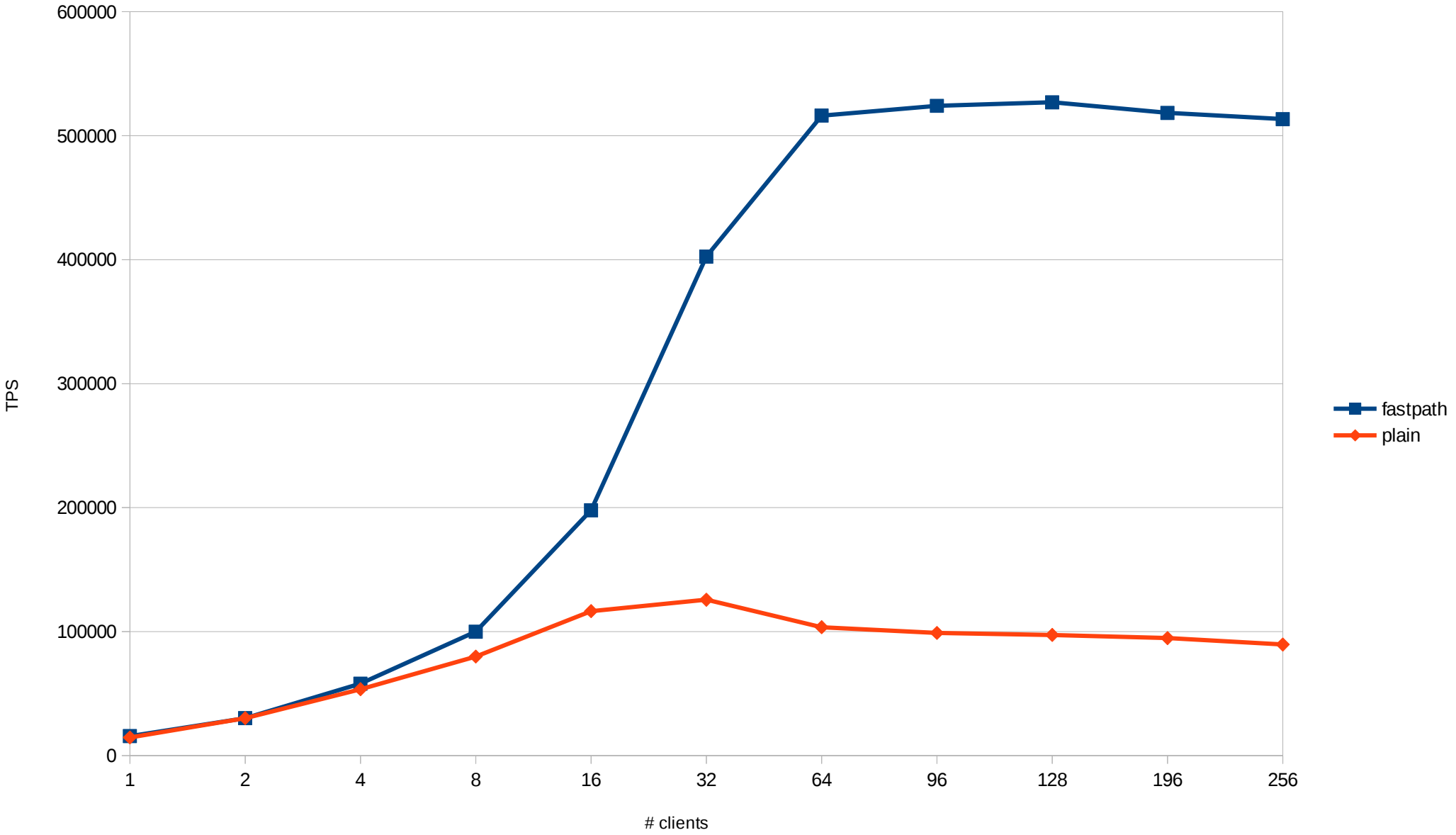
# Heavyweight Lock - Fastpath



# Heavyweight Lock – Slow Path






- readonly pgbench scale 300
- EC2 m4.8xlarge - 2 x E5-2676
- master @ aa6b2e6
- fastpath disabled in code

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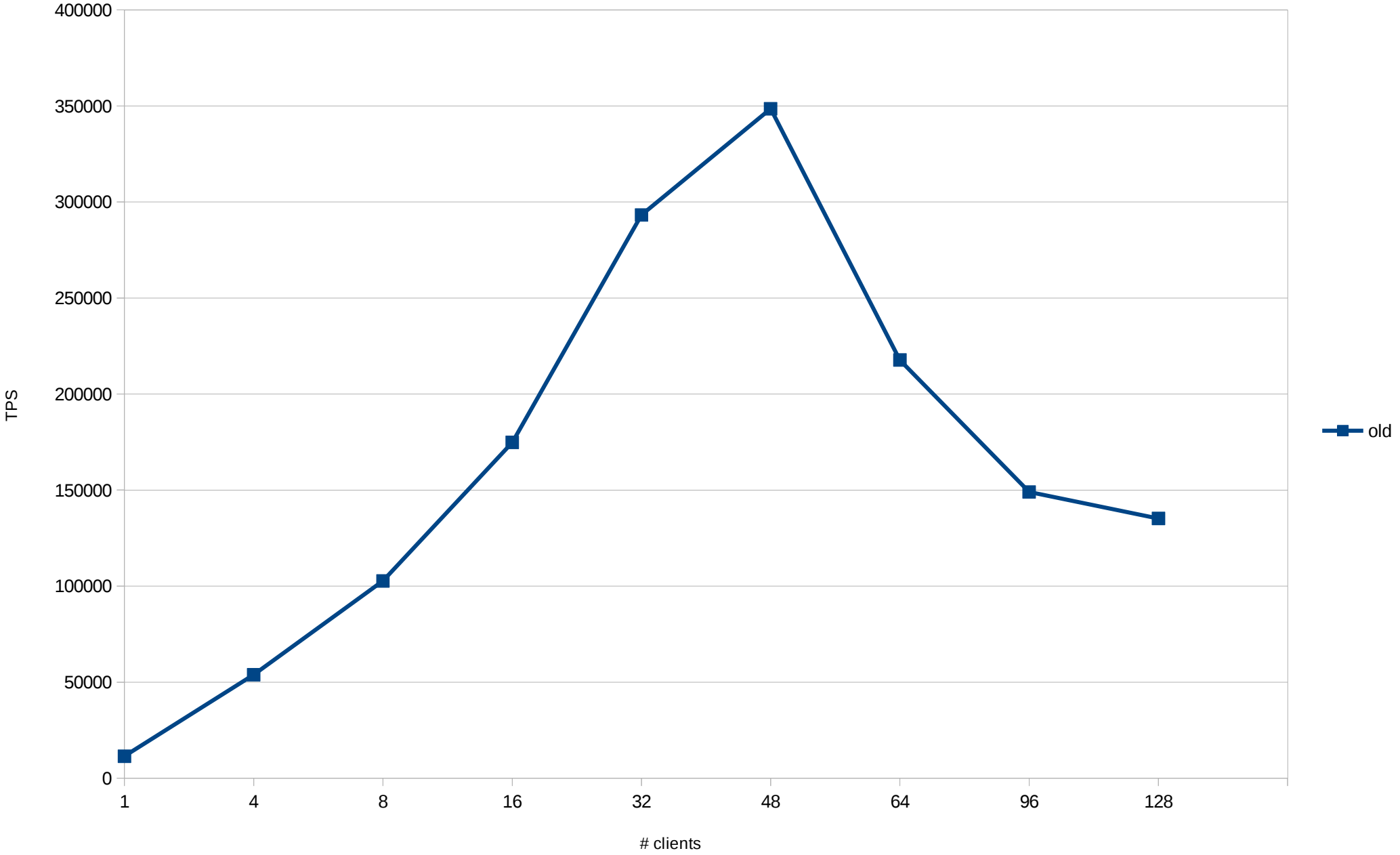
# LWLock scalability

```
# perf top -az
     89.53%  postgres  postgres  [.] s_lock
      2.53%  postgres  postgres  [.] LWLockAcquire
      1.79%  postgres  postgres  [.] LWLockRelease
      0.63%  postgres  postgres  [.] hash_search_..._value
```

```
LWLockAcquire(LWLock *l, LWLockMode mode)
{
  retry:
    SpinLockAcquire(&lock->mutex);

    if (mode == LW_SHARED)
    {
        if (!lock->exclusive)
        {
            lock->shared++;
        }
        else
        {
            QueueSelf(l);
            SpinLockRelease(&lock->mutex);
            WaitForRelease(l);
            goto retry;
        }
    }
    ...
    SpinLockRelease(&lock->mutex);
}
```




- readonly pgbench
- 4xE5-4620 (4 x 8 cores/16 threads)
- scale 100

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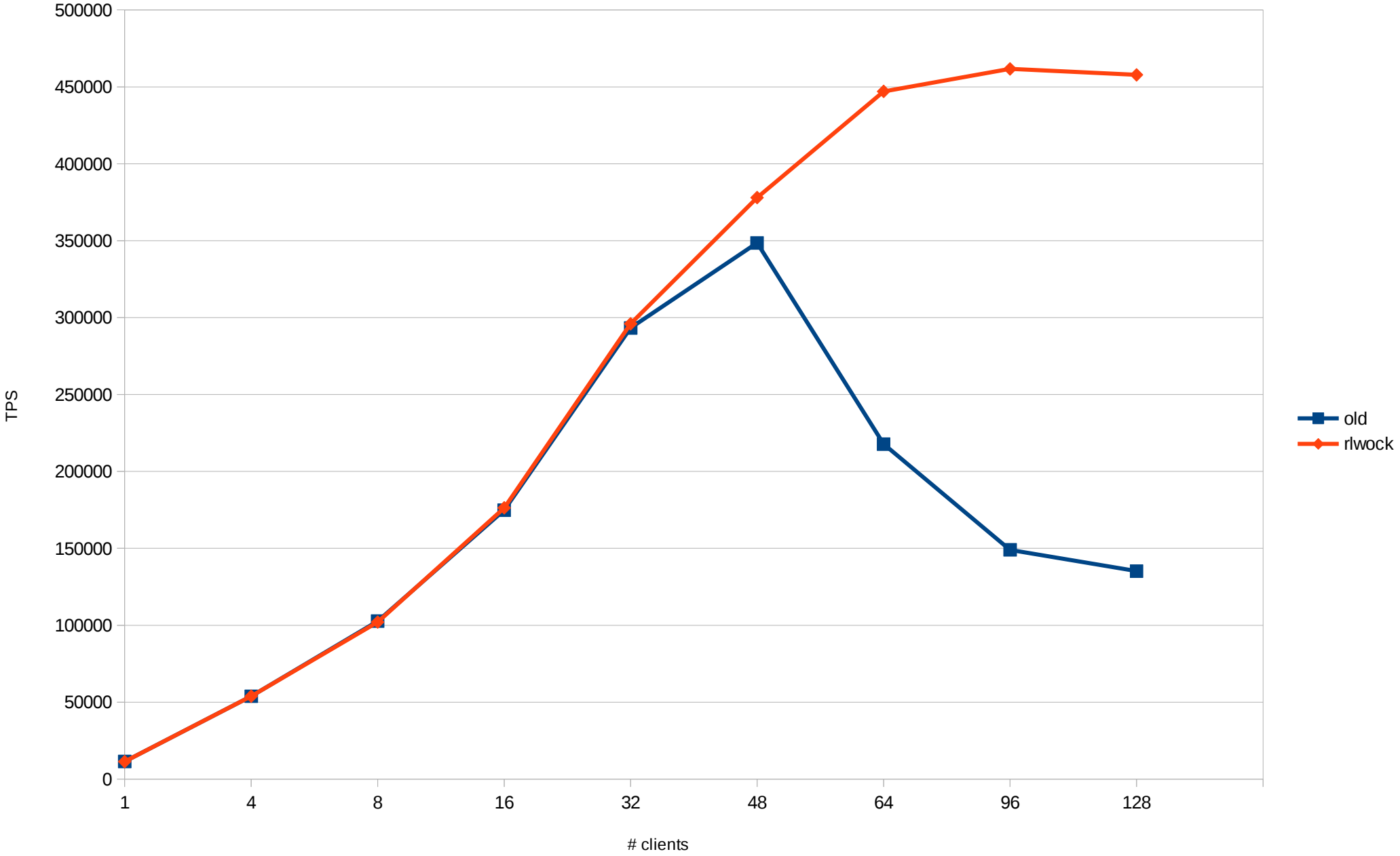
# Fix this!

- Use atomic operations
  - atomic add & subtract, compare exchange
- Complex, due to queuing

```
if (!atomic_try_acquire(lock, mode))
{
    QueueSelf();
    if (!atomic_try_acquire(lock, mode))
        WaitForRelease();
        goto retry;
    else
        UnQueueSelf();
}
```




- readonly pgbench
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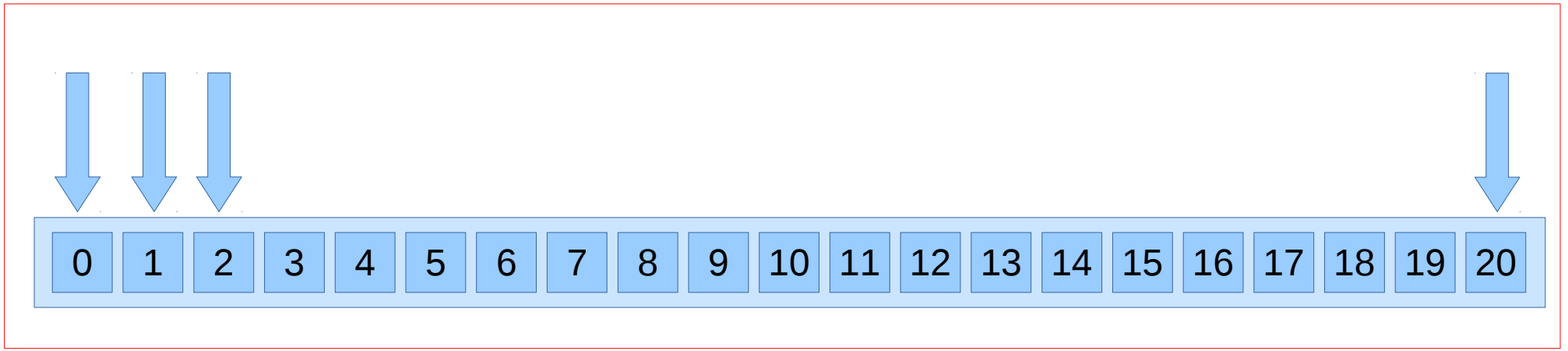
# Buffer Descriptors & Buffers

```
struct BufferDesc
{
    BufferTag   tag;          /* ID of page contained in buffer */

    uint16      usage_count;  /* usage counter for clock sweep */
    unsigned    refcount;     /* # of backends holding pins */

    slock_t     buf_hdr_lock; /* protects the above fields */
} BufferDesc;
```

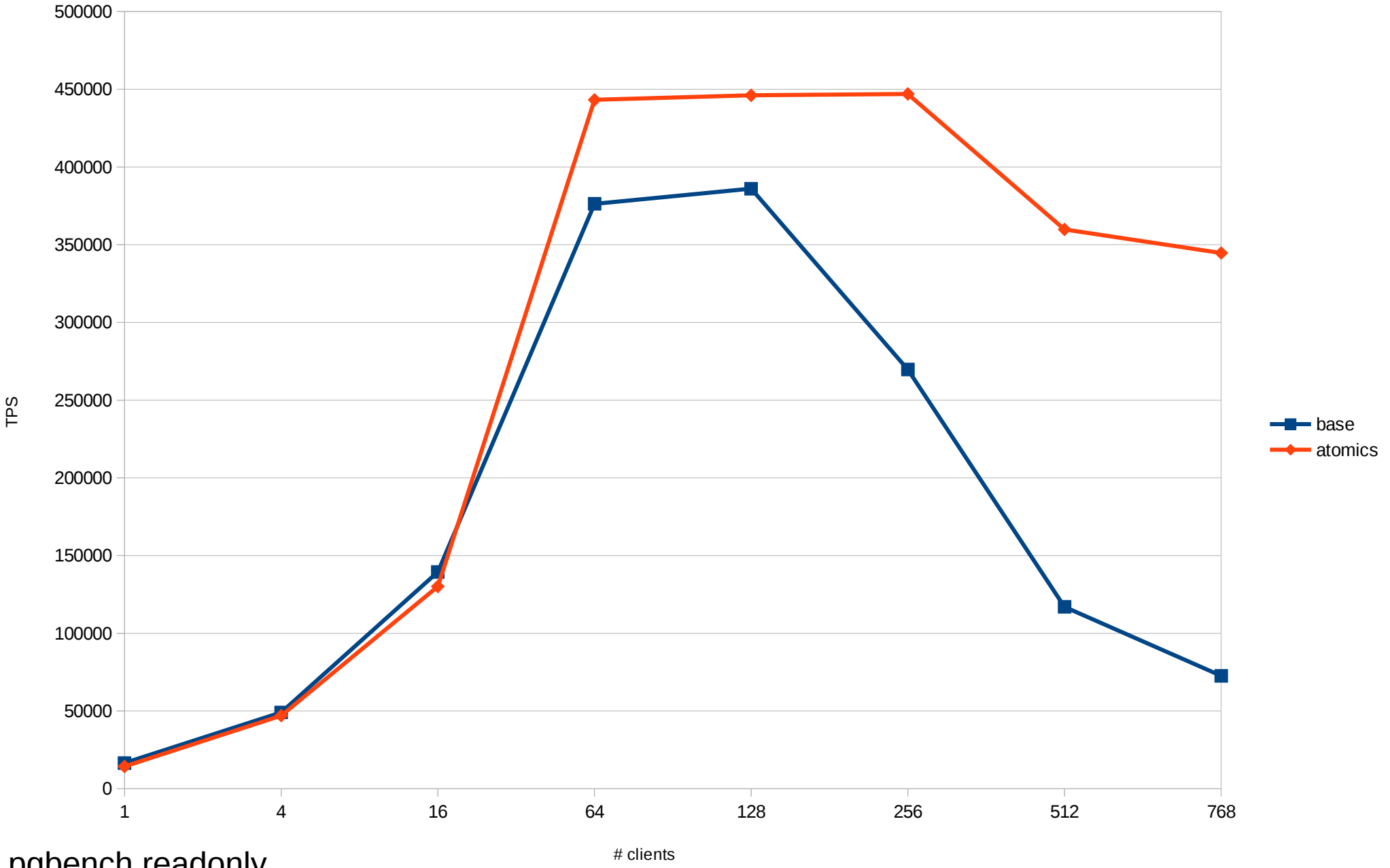
# Inefficient Buffer Replacement



# Fix It

- granular locking: spinlock per clock tick
- atomics:

```
victim = pg_atomic_fetch_add_u32(
    &StrategyControl->nextVictimBuffer, 1);
victim = victim % NBuffers;
```




- pgbench readonly
- scale 1000 (~14GB)
- 4GB shared buffers
- EC2 m4.8xlarge - 2 x E5-2676
- master @ aa6b2e6

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# Scalability Approaches

- Avoid locks in common cases
- More efficient locking
- Atomic operations
- More granular locking

# Not Fixed – Query Parallelism

- Each query only use one core
  - fine for transactional workloads
  - horrible for analytics workloads
- Initial parallelism Infrastructure in 9.5 u. 9.6
- First parallel queries hopefully in 9.6
  - will take a while to work for many types of query constructs

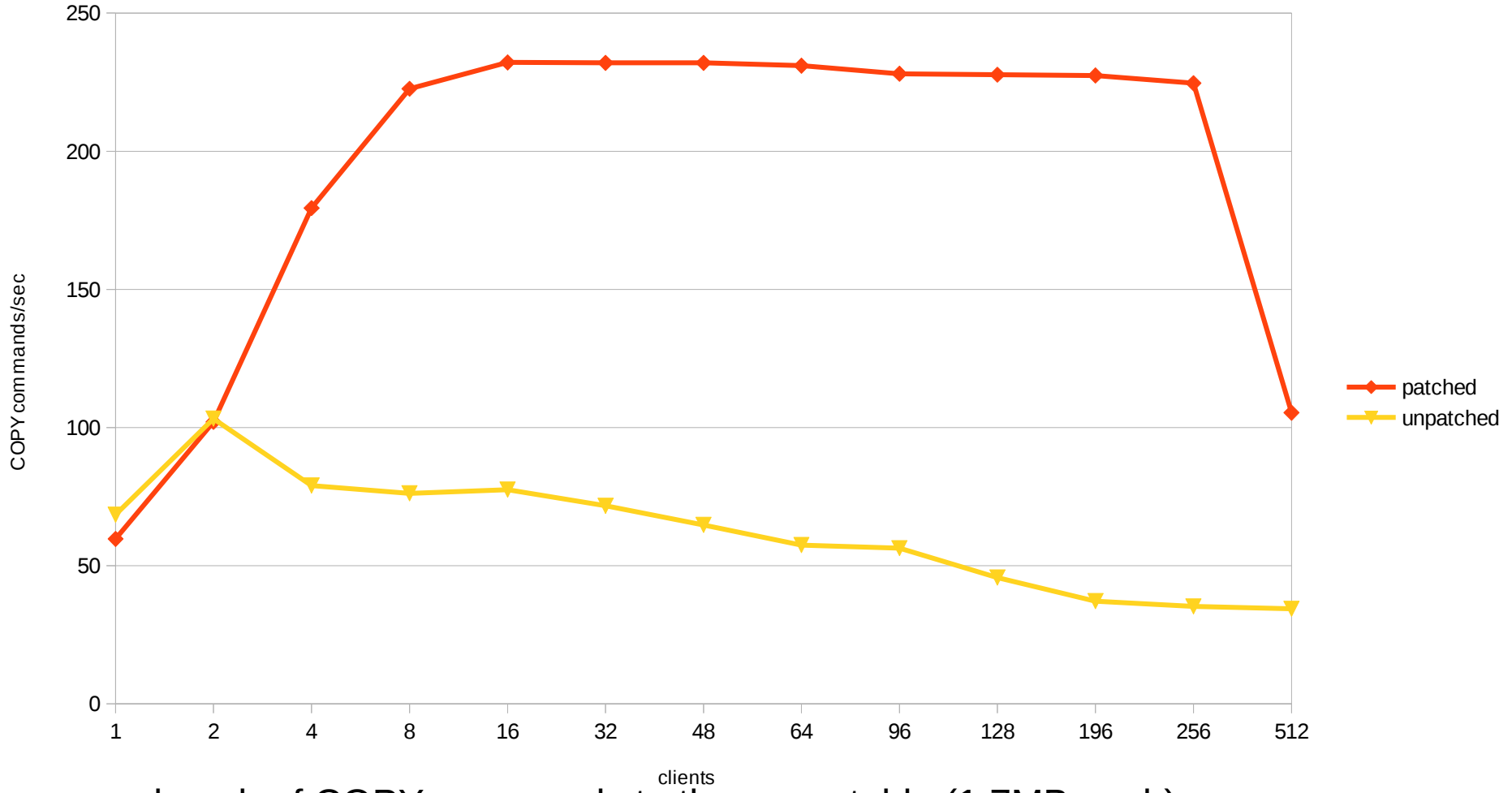
# Further Scalability Issues

- Expensive Snapshot Computation
  - Problematic: High QPS (combined read & write) workloads, many clients
  - Solution: connection pooler
- Extension Lock
  - Problematic: Parallel bulk write workloads to single table
  - Workaround: Uh.
  - Fix hopefully in 9.6
- Buffer Replacement Complexity & Accuracy
  - Problematic: Larger than memory workloads
  - Solution: Try higher or lower shared_buffers

# Help!

- Contribute Problems
  - detailed descriptions of things being to slow
  - detailed descriptions of things you'd like to do
- Contribute Solutions
  - fix things that are too slow
- Contribute Contributions
  - help others to contribute

# Extension Lock Scalability




- pgbench of COPY commands to the same table (1.7MB each)
- 4xE5-4620 (32 cores, 64 threads)
- 48 GB shared memory, 256 GB in total

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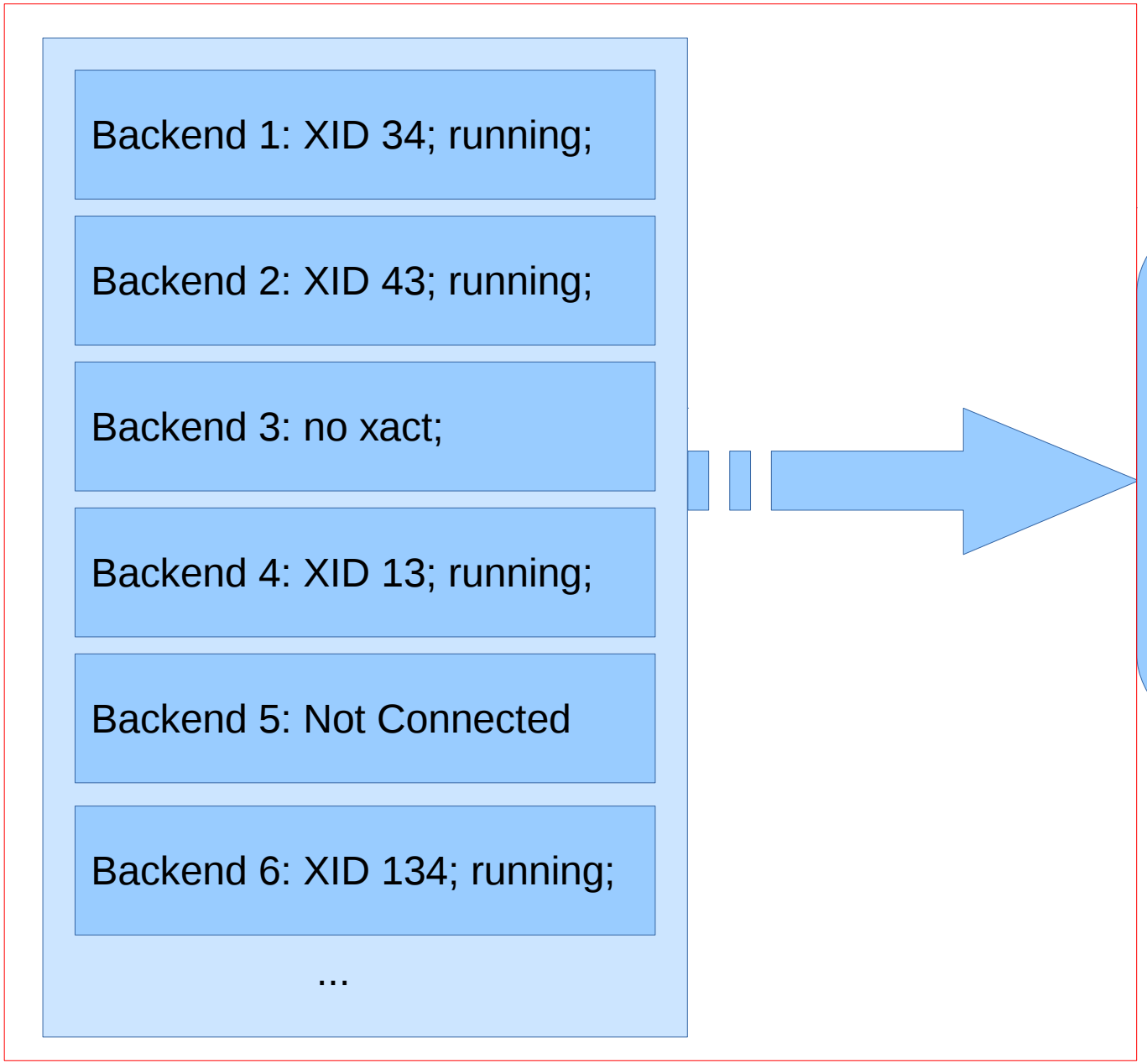
# Expensive Snapshot Computation

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