Redis as a Reliable Work Queue
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Introduction

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Bronto Features

- Communication
  - Email
  - Social
  - SMS
- Contact Management
  - Manual
  - Segmentation
- Marketing Automation
  - Workflows
- Commerce Integration
  - Purchase History
  - Cart Recovery
- Integration
  - SOAP/REST API
  - Third Party Connectors
## Introduction

### Cyber Monday 2014

#### Peak Daily Totals

<table>
<thead>
<tr>
<th>Emails Sent</th>
<th>Events Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>~170M per Day</td>
<td>~400M per Day</td>
</tr>
<tr>
<td>~2000 per Second</td>
<td>~4700 per Second</td>
</tr>
</tbody>
</table>

#### Peak Hourly Totals

<table>
<thead>
<tr>
<th>Emails Sent</th>
<th>Events Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>~14M per Hour</td>
<td>~32M per Hour</td>
</tr>
<tr>
<td>~3900 per Second</td>
<td>~8900 per Second</td>
</tr>
</tbody>
</table>
Distributed Work Queueing

Local work queues...
Distributed Work Queueing

Local work queues...handle failure poorly

- Excessive Growth
- Lost or Orphaned
Distributed Work Queueing

Local work queues...handle unbalanced loads poorly
Distributed Work Queueing

Local work queues... may be bad neighbors
What about putting the work in a relational database?
Distributed Work Queueing

What about putting the work in a relational database? Please don’t do that…

Why are they doing this to me?
Distributed work queues...
Distributed work queues...decouple producers and consumers
Distributed work queues...are more fault tolerant
Distributed work queues... partition for availability and/or scale
Great... But where can I get one?

- Kafka
- Kestrel
- Starling
- BeanstalkD
- SwiftMQ
- RabbitMQ
- ActiveMQ
- Qpid
- Apollo
- SQS (Simple Queue Service)

...and lots more I’ve simply forgotten or ignored

There are plenty of options in this space.
Distributed Work Queueing

Why did we go with Redis?

- Existing deployment
- Existing operational experience
- Existing development experience
- Works well without specialized hardware
- Favorable balance of throughput vs. durability
- Flexibility to support alternate queue schemes (e.g. with key-based aggregation)

We don’t regret building this on Redis, and we feel it will be a solid contribution to the open source ecosystem.
Redis

The fundamentals...

- NoSQL database
- Key/Value style
- Data structures
- Memory only
- Durable to disk
- Fast, fast, fast
Under the covers…

- C application
- Single threaded
- Strongly consistent
- Durability via snapshots (RDB)
- Durability via redo logs (AOF)
- Scriptable on server-side (LUA)
- Simple protocol
- Replication
Redis

Is it ACID? No...

Single Operations
- Atomic
- Consistent
- Isolated

Multi Operation Transactions
- Atomic
- Isolated

Server Scripted Transactions
- Atomic
- Isolated

Redis is not consistent per ACID because it does not support rollbacks.
Redis is not durable per ACID because it does not require persistence to disk.
Redis

Durability in Redis

RDB (Redis Database)

- Point in time snapshot
- Scheduled or on-demand
- Performed in a forked process
- Compact file format
- Fastest restore time
- Larger window for data loss

There are workloads that can make good use of the scheduled and/or explicit RDB snapshots, but the queue case is not one of them.
Redis

Durability in Redis

AOF (Append Only File)

- Streaming log of operations
- Periodic log rewriting from live data via fork
- Reduced chance of corruption due to append only strategy
- Multiple fsync() policies
  - Never
  - Every second
  - Every operation
- Slightly reduced performance due to more frequent disk interaction

AOF with the ‘every second’ fsync policy is a good fit for us.

- No expected data loss due to process failure
- One second of potential data loss due to machine failure
Naïve Queueing

Producer creates work payload
Naïve Queueing

LPUSH my_queue work
Naïve Queueing

RPOP my_queue
Naïve Queueing

Consumer processes work

Redis

Service Producer

Service Consumer

work
Naïve Queueing

…but what if something goes wrong?
Reliable Queueing

Naïve Queueing

Created → enqueue → Pending → dequeue → Complete

Reliable Queueing

Created → enqueue → Pending → dequeue → Working → release → Complete

Delayed

time → delay

requeue
Reliable Queueing

Redis and LUA Scripting

Think of it as a stored procedure.

- Loaded via EVAL
- Invoked via EVALSHA
- Atomic execution

```lisp
-- Move the ready UUIDs from the delayed set back into the pending list.
-- These UUIDs are ready when their ZSCORE is less than that of the current time "now",
-- passed in as a parameter to this function.
-- They will be added back to the front of the pending list, rather than the end of it.
local function requeueDelayed(pendingList, delayedZSet, now)
  -- Get the UUIDs of the items ready to be requeued from the delayed set
  local ready_uuids = redis.call('ZRANGEBYSCORE', delayedZSet, 0, now)

  if #ready_uuids == 0 then
    return 0
  end

  -- Move the items from the delayed set to the front of the pending list
  zrem_safe(delayedZSet, ready_uuids)
  rpush_safe(pendingList, ready_uuids)

  return #ready_uuids
end
```
Redis Reliable Queueing

enqueue()
enqueue()
1. Generate {UUID}
2. LPUSH my_queue_pending {UUID}
3. HSET my_queue_values {UUID} {work}
Reliable Queueing

The work is now in the *pending* state.

Redis

- **my_queue** (LUA)
- **my_queue_pending** (LIST)
- **my_queue_working** (ZSET)
- **my_queue_values** (MAP)

Service Producer

Service Consumer

```
my_queue (LUA)
my_queue_pending (LIST)  my_queue_working (ZSET)
my_queue_values (MAP)
```

```
work
```
Reliable Queueing

dequeue()
**Redis Reliable Queueing**

**dequeue()**

1. RPOP my_queue_pending
2. ZADD my_queue_working {timestamp} {UUID}
3. HGET my_queue_values {UUID}
4. Return {work} to consumer
The work is now in the *working* state, safely dequeued, with an immutable copy still on the Redis server.
release()
release()
1. ZREM my_queue_working {UUID}
2. HDEL my_queue_values {UUID}
The work is now in the *completed* state, completely processed, with no copy remaining in Redis.

- **my_queue** (LUA)
- **my_queue_pending** (LIST)
- **my_queue_working** (ZSET)
- **my_queue_values** (MAP)
Reliable Queueing

What if something goes wrong during processing?

Redis

- my_queue (LUA)
- my_queue_pending (LIST)
- my_queue_working (ZSET)
- my_queue_values (MAP)

Service Producer

Service Consumer

BOOM
requeue()
requeue()
1. ZREM {UUID}
2. LPUSH {UUID}
The work has now returned to the *pending* state, and will be reissued as soon as it returns to the head of the queue.
What if something **really** goes wrong during processing?

Redis

- my_queue (LUA)
- my_queue_pending (LIST)
- my_queue_working (ZSET)
- my_queue_values (MAP)

Service Producer

Service Consumer

BOOM
Redis

Reliable Queueing

sweep()
sweep()
1. ZRANGEBYSCORE my_queue_working 0 {timestamp – stale}
2. LPUSH my_queue_pending {UUIDs}
3. ZREM {UUIDs}
The work has now returned to the *pending* state, and will be reissued as soon as it returns to the head of the queue.
Reliable Queueing

The real implementation does a lot more...

- Asynchronous API
- Operation pipelining
- Opportunistic batching
- Pre-fetching
- Per-item deferment
- Per-item statistics
  - Enqueue time
  - Dequeue time / count
  - Requeue time / count
- Metrics instrumentation
  - Queue throughput & timing
  - Batching effectiveness
  - Queue size
  - Queue lag
Some benchmarks...

- Bronto’s Redis Client implementation
- Bronto’s Reliable Queue implementation
- Redis running on Intel(R) Xeon(R) CPU E5-2430 @ 2.20GHz
- All tests are single threaded, with one connection
- All tests use single byte queue name and item payload

<table>
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<tr>
<th>Scenario</th>
<th>Enqueue</th>
<th>Dequeue &amp; Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pipelining, No batching</td>
<td>6,700 items/sec</td>
<td>2,900 items/sec</td>
</tr>
<tr>
<td>Pipelining (1024), No batching</td>
<td>62,040 items/sec</td>
<td>14,029 items/sec</td>
</tr>
<tr>
<td>Pipelining (1024), Batching (256)</td>
<td>236,922 items/sec</td>
<td>70,706 items/sec</td>
</tr>
</tbody>
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We are planning on releasing the entire suite to the open source community.

- **Redis Client**
  - Asynchronous
  - Pipelining
  - Protocol access
  - Scripting supports

- **Redis Benchmarking Tools**
  - Scriptable benchmark runs
  - Support for rapid LUA iteration and testing

- **Bronto’s Reliable Queue implementation**
  - Everything you just heard about
Bronto Open Source

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Coming this Spring.
Thanks for listening!

Questions?