Intro to Distributed Systems w/ ZeroMQ

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Is it ZeroMq or 0MQ?

- ZeroMq, ØMQ, 0MQ, zmq
- Official site: http://zeromq.org

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Origin Story

- Pieter Hintjens
  - CEO iMatix
  - 2007-2016
- Martin Sustrik
  - Software Architect / Lead Developer
  - 2007-2011
- JPMorganChase
  - 2004; need for new msg protocol 10K msg/sec => 100K msg/sec
  - Authored OpenAMQ (Advanced Message Queuing) protocol
- DowJones & Co
  - Hired to integrate into data distribution systems

Imatix

- Pieter felt AMQ community was ‘toxic’; “don’t try to fix organizations, start new ones”
- Joined iMatix focused on development of ZeroMq
- Difference of opinion between Martin & Pieter resulted in Martin leaving ZeroMq community and starting nanomsg
- Pieter emphasizing on ‘community’, Martin having expertise in authoring messaging libraries

What is ZeroMq?

- Broad spectrum of what it can be viewed as:
  - ‘sockets on steriods’
  - ‘mailboxes with routing’
  - Communication framework for creating robust distributed computing
    - RPC & Client/Server model
    - One-way distribution
    - Pipeline
- Multi-language
  - 52 languages (and counting)
- Multi-platform
  - Runs on ‘everything of interest’, not limited to Windows, Linux, MacOS, embedded, Android…..
- Multi-Transport Protocols
  - TCP, UDP, IPC, INPROC, PGM, EPGM

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ZeroMq Core Concepts

- Born out of the financial industry
- As open-source products go, extremely well documented
  - RFC Standard
  - Comprehensive User/Developer Guide
- Library rather than suite of services
- Mechanism to build highly distributed systems
  - Library
  - Common Distributed System Recipes/Patterns

What's the Zero Stand For?

- '0' stands for:
  - Zero broker
    - Library vs broker service
  - Zero latency
    - Emphasis on speed/efficiency
    - Small framing protocol
  - Zero cost
    - Formula 1 design model; make it fast, then reliable
  - Zero waste
    - Distributed systems captialize on available h/w, reducing specialized hw, reducing waste
-

Design Considerations

- How do we handle I/O?
  - Background communication engines
  - Lock-free data structures
  - No need for client application locking mechanisms
  - ZeroMQ sockets contain queues
- How do we handle dynamic components?
  - Component can come/go and ZeroMQ automagically reconnects
- How do we represent the message on the wire?
  - Len + envelope + payload
  - Does not impose format on messages, ‘blobs’, BYO protocol buffer
- What if we can’t deliver the message immediately?
  - Message delivery can be viewed at ‘atomic’, all-or-nothing and asynchronous

Design Considerations (continued)

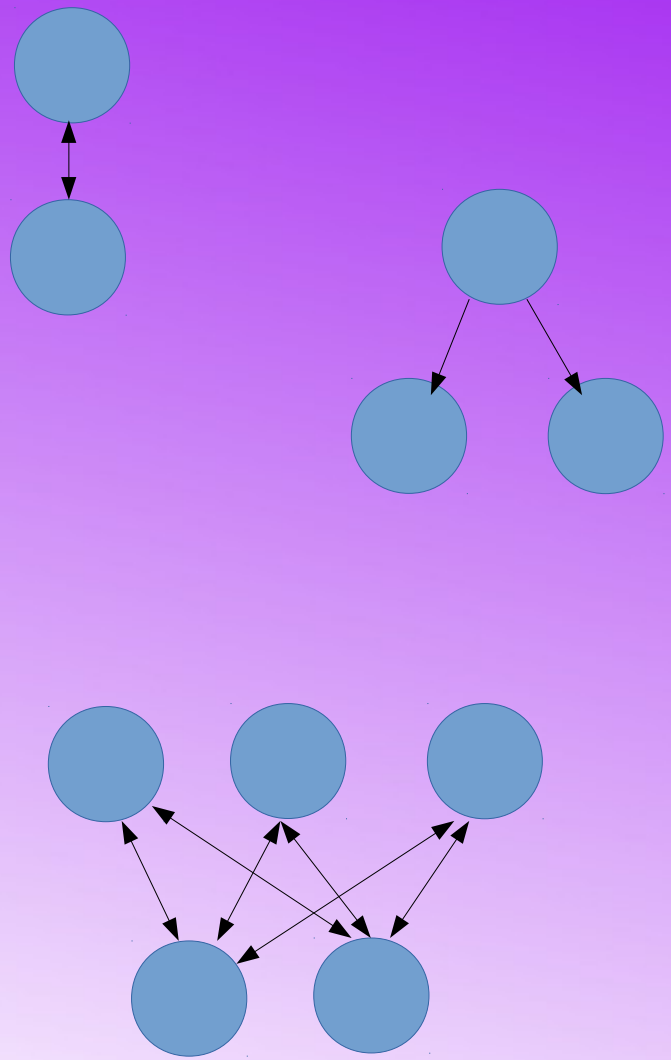
- How do we address slow consumers?
  - Dependent on messaging pattern
- How do we address lost messages?
  - All-or-Nothing, background communication engine
- What if we need to use a different network transport?
  - Singlular API, no need to change code for alternative transport
- How do we route messages?
  - Routing part of the messaging patter
- APIs for alternative languages?
  - 50+ languages supported
- How do we represent data for heterogeneous architectures?
  - Provides network marshalling
- How do we handle network errors?
  - Background tasks + retry provides robust delivery

Socket Types

- With ZeroMQ, the term ‘socket’ has a less primitive meaning
- Built in queuing
- Personalities
  - PUB
  - SUB
  - REQ
  - REP
  - ROUTER
  - DEALER
  - PUSH
  - PULL
  - PAIR

Node / Connectors

- Node Connection Types
  - Connection Cardinality
  - Connection Directionality



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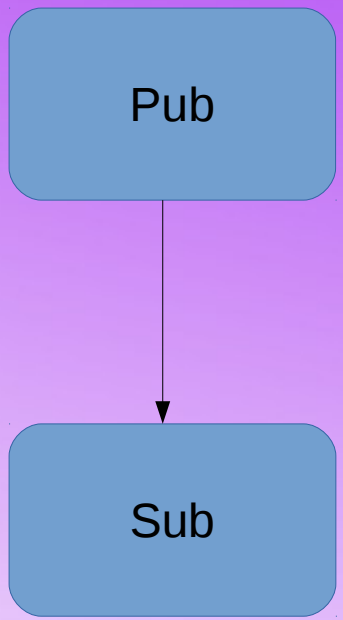
Pub / Sub 1-1



Observer pattern; ‘topics’

Radio broadcast; miss everything before you begin listening

```
lipeltgm@kaylee:~/IntroToZeroMq/PubSub1-1$ cat -n pub
     1  #!/usr/bin/python
     2  import sys;
     3  import zmq;
     4  from random import randrange;
     5  import time;
     6
     7  port=int(sys.argv[1]);
     8  ctx = zmq.Context();
     9  socket=ctx.socket(zmq.PUB);
    10  socket.bind('tcp://*:%s'%port);
    11
    12  topic='TopicXX';
    13  while True:
    14    print "publishing";
    15    socket.send('%s %s'%(topic, randrange(0,100)));
    16    time.sleep(1);

lipeltgm@kaylee:~/IntroToZeroMq/PubSub1-1$ cat -n sub
     1  #!/usr/bin/python
     2  import sys;
     3  import zmq;
     4
     5  port=int(sys.argv[1]);
     6  ctx = zmq.Context();
     7  socket=ctx.socket(zmq.SUB);
     8  socket.connect('tcp://localhost:%s'%port);
     9
    10  topic='TopicXX';
    11  socket.setsockopt_string(zmq.SUBSCRIBE, topic.decode('ascii'));
    12
    13  while True:
    14    S=socket.recv();
    15    print "S: %s"%(S);
```

Disconnected TCP, 1-N

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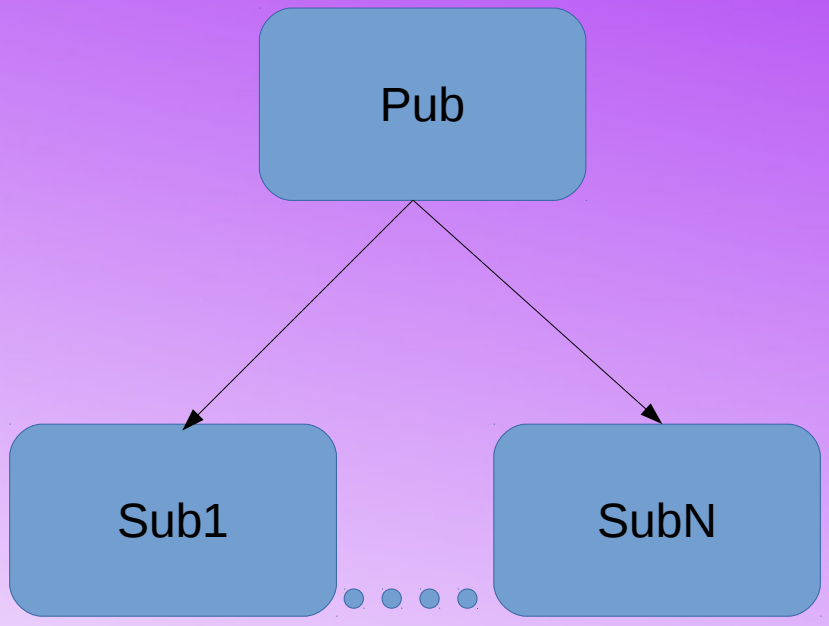
Pub / Sub 1-N

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```

No Need To Modify To Code

```
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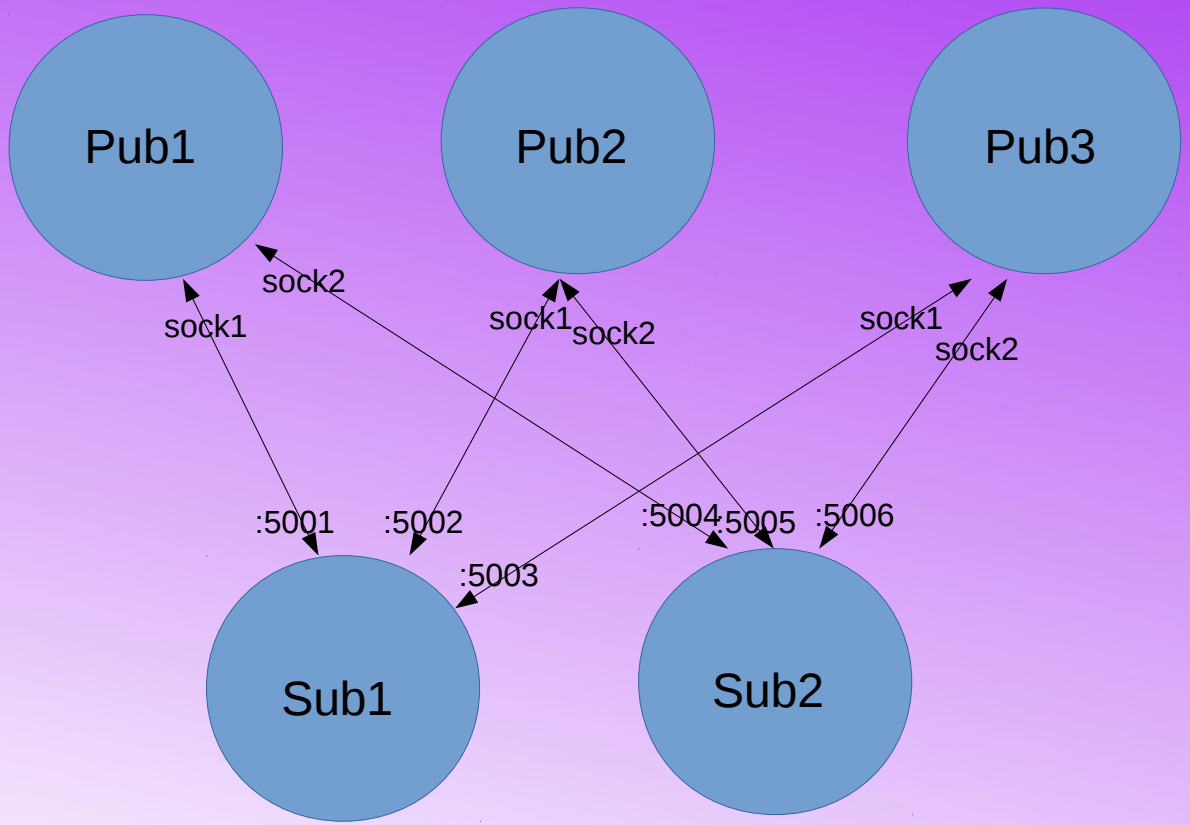
Pub / Sub N-M



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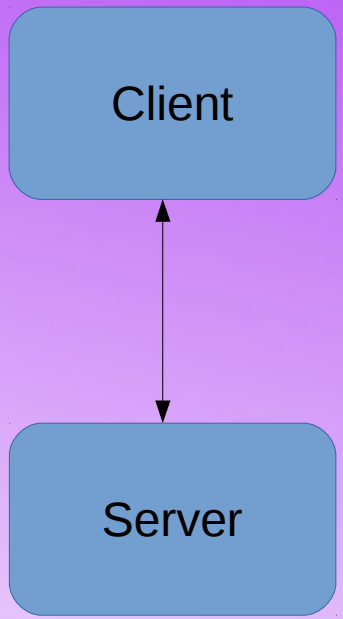
Request / Reply 1-1



Enforces ::send() / ::recv() protocol

```
lipeltgm@kaylee:~/IntroToZeroMq/ReqRep1-1$ cat -n client
     1  #!/usr/bin/python
     2  import zmq;
     3  import sys;
     4  import time;
     5
     6  port=int(sys.argv[1]);
     7  ctx=zmq.Context();
     8  socket=ctx.socket(zmq.REQ);
     9  socket.connect('tcp://localhost:%d'%(port));
    10
    11  while (True):
    12    time.sleep(1);
    13    socket.send('ping');
    14    S=socket.recv();
    15    print "got reply: %s"%(S);

lipeltgm@kaylee:~/IntroToZeroMq/ReqRep1-1$ cat -n server
     1  #!/usr/bin/python
     2  import zmq;
     3  import sys;
     4  import time;
     5
     6  port=int(sys.argv[1]);
     7  ctx=zmq.Context();
     8  socket=ctx.socket(zmq.REP);
     9  socket.bind('tcp://*:%d'%(port));
    10
    11  while (True):
    12    S=socket.recv();
    13    print 'got: %s'%(S);
    14    socket.send('pong');
```

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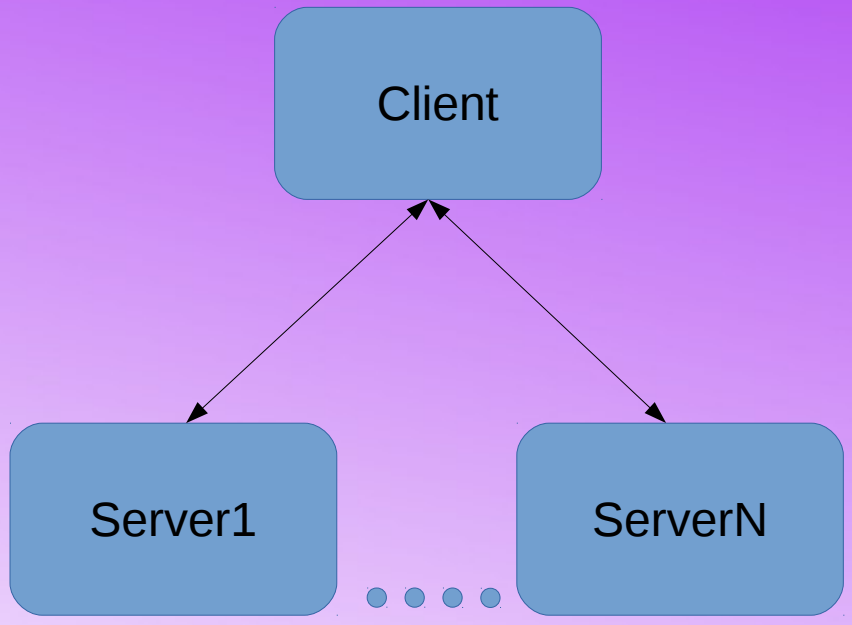
Request / Reply 1-N



Enforces ‘fair queuing’ protocol

```
lipeltgm@kaylee:~/IntroToZeroMq/ReqRep1-N$ cat -n client
     1  #!/usr/bin/python
     2  import zmq;
     3  import sys;
     4  import time;
     5
     6  port1=int(sys.argv[1]);
     7  port2=int(sys.argv[2]);
     8  ctx=zmq.Context();
     9  socket=ctx.socket(zmq.REQ);
    10  socket.connect('tcp://localhost:%d'%(port1));
    11  socket.connect('tcp://localhost:%d'%(port2));
    12
    13  while (True):
    14    time.sleep(1);
    15    socket.send('ping');
    16    S=socket.recv();
    17    print "got reply: %s"%(S);
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    11  while (True):
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    13    print 'got: %s'%(S);
    14    socket.send('pong');
```

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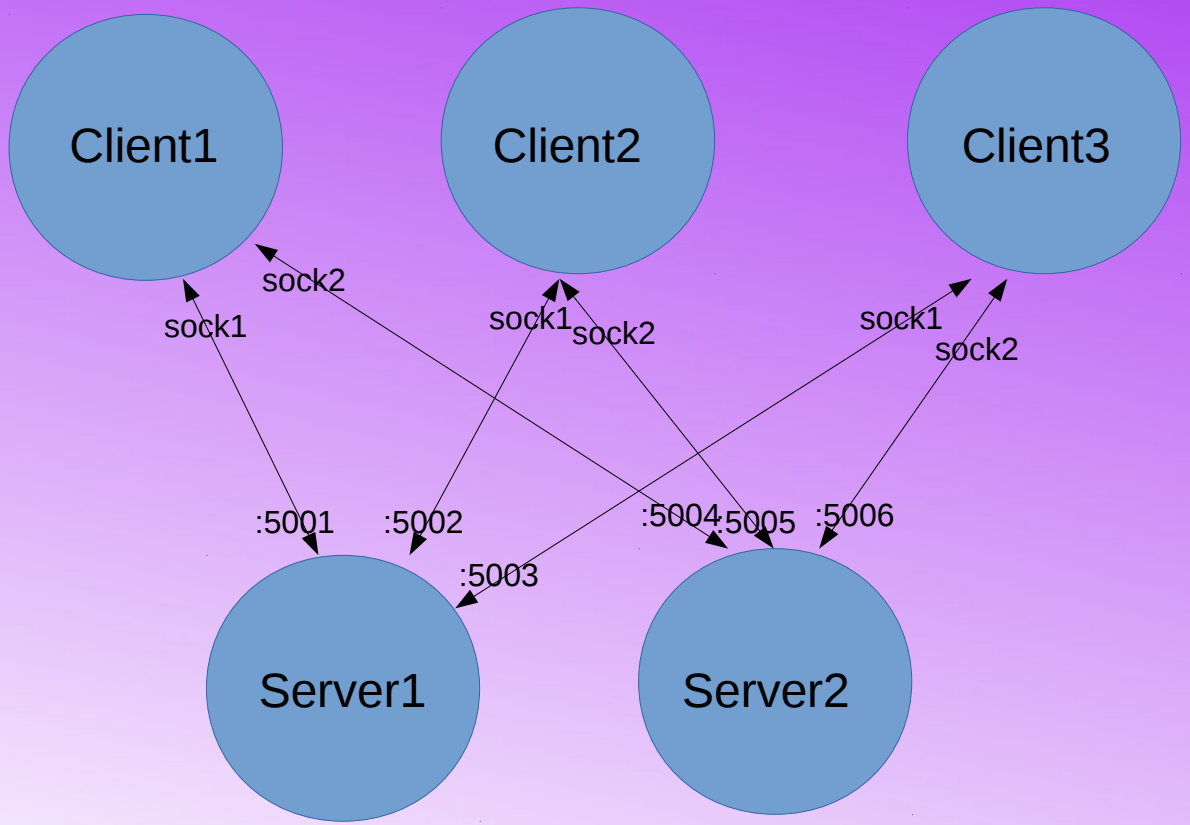
Request / Reply N-M



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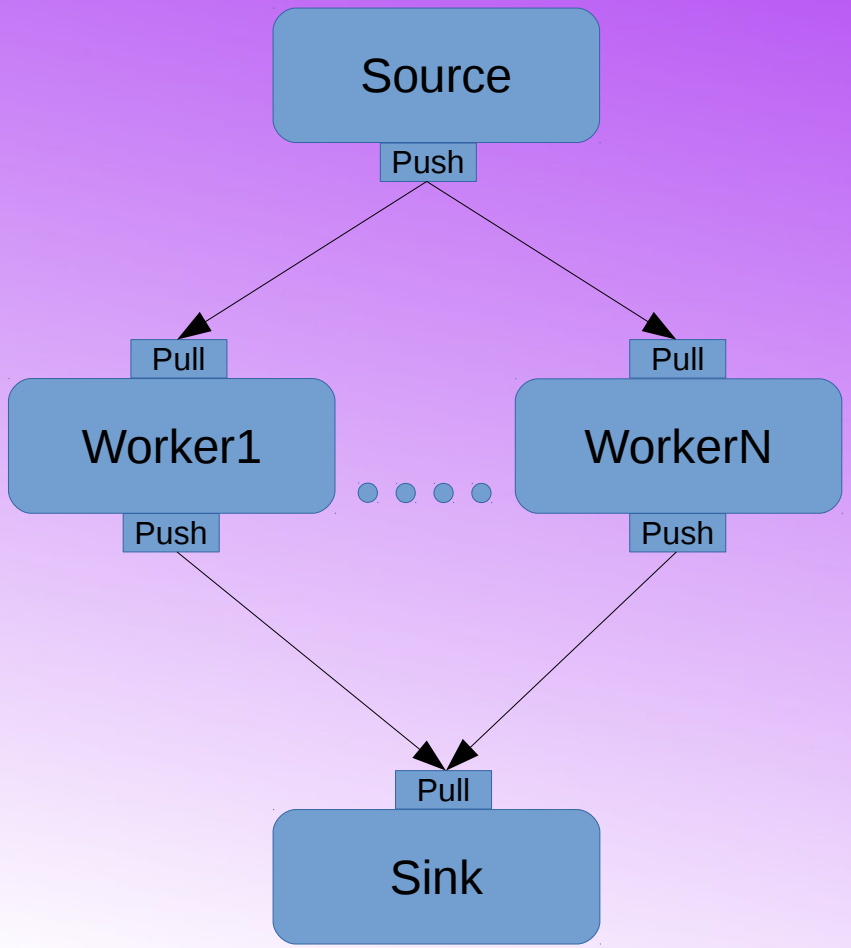
Parallel / Pipeline 1-N



- Distributed / Parallel Processing Architecture

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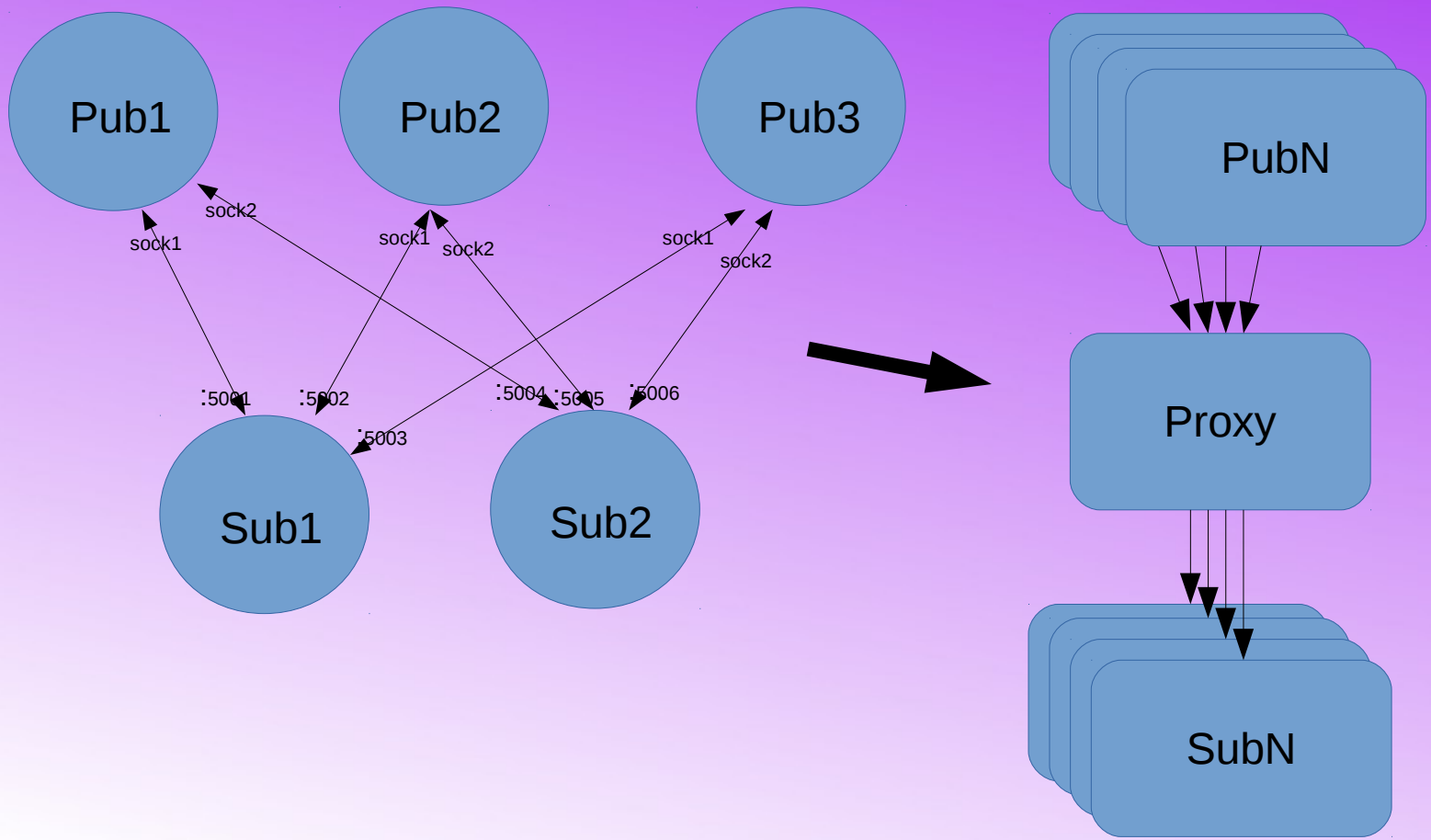
Data Distribution w/Intermediary

Pub/Sub



- XPUB/XPUB Sockets provide proxy mechanism
- XPUB/XSUB expose subscriptions as special messages,
- Forward subscription messages from subscriber to publisher

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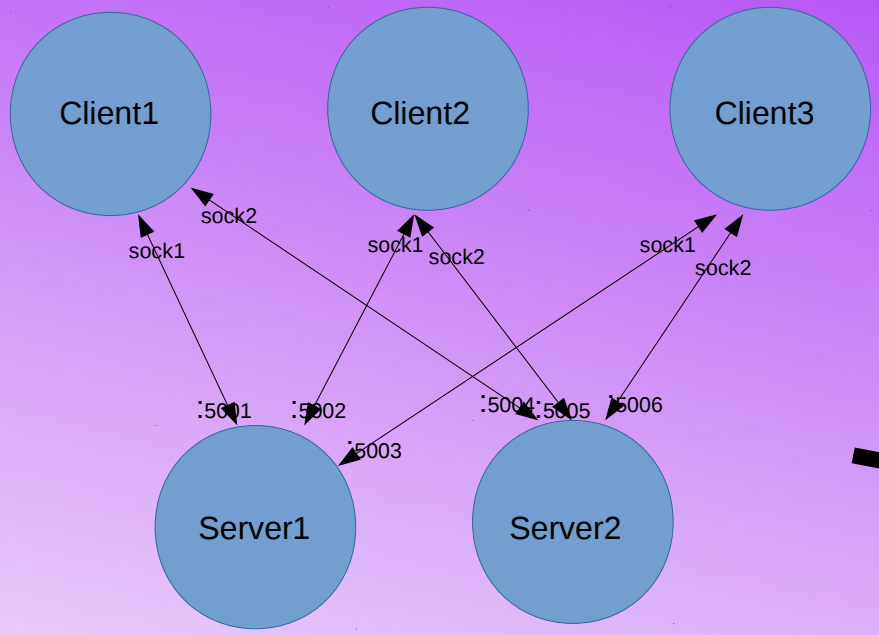
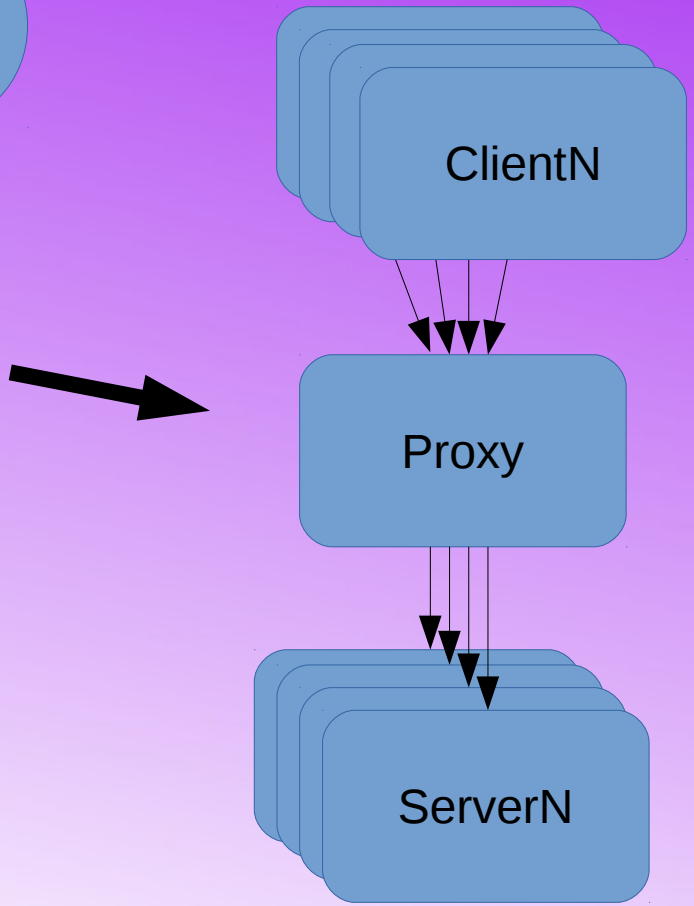
Data Distribution w/Intermediary
Req/Rep





- ROUTER/DEALER socket pairing performs the magic

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Advanced Messaging Patterns

- The Lazy Pirate pattern: reliable request/reply from the client side
- The Simple Pirate pattern: request/reply using load balancing
- The Parnoid Pirate pattern: reliable request/reply with heartbeating
- The Majordomo pattern: service-oriented reliable queuing
- The Titanic pattern: disk-based/disconnected reliable queuing
- The Binary Star pattern: primary-backup server failover
- The Freelance pattern: brokerless reliable request/reply

Quick Summary

- ZeroMq was authored as a library-based high-performance messaging framework
- Multi-language & multi-platform multi-tool
- Message contents are considered ‘blobs’, bring your own protocol buffer or simply use string
- Queuing/Asynchronous deliver via background delivery engines
- Flexible design componentry to support quick/simple peer-to-peer to advanced message broker, heartbeating, dynamic heterogeneous nodes
- Advanced patterns to common distributed system challenges
- Substantial documentation and support community, ZeroMQ Guide is detailed document with light humor, worth the read
- Now, go build something cool.

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Contact Info

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