Using ZeroMQ for GEP

ØMQ

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Atlanta, Georgia

About ZeroMQ

- The “zero” in ZeroMQ
  - Zero Broker
  - Zero Latency (Low Latency)
  - Zero Administration
  - Zero Cost – Cross Platform & Open Source
- Allows complex messaging exchange patterns with minimal effort
- Scalable for distributed or concurrent applications

ZeroMQ Benefits

- Numerous language and platform integration points – all integrated and compatible
- Small and light-weight with the performance to support high-volume phasor data flows
- Larger variety of message patterns with a range of loss/reliability characteristics – pub/sub; client/server; brokered.
- Content of the message flexible and easily accommodates phasor measurement pattern – ID, Timestamp, value, flags
- In practice, ZeroMQ is used to manage the socket layer on behalf of the application
- Ability to scale well is inherent in architecture -- scales easily from intra-application communication, to inter-application communication to wide-area communication

ZeroMQ vs. DDS

- DDS
  - Pros: Mature "middle-ware" layer supporting mission critical apps, extensive number of options
  - Cons: Heavy-weight, slower, steep learning curve, no open source standards based security yet

- ZeroMQ:
  - Pros: Many messaging patterns, extensive language implementations, fully open source with security, light-weight, faster
  - Cons: Lower level API, not as many features as DDS for options like discovery, delivery deadlines and QoS

Summary of CERN* Evaluated Middleware

	patterns	QoS	resources	performance	user friendly	community	score
CORBA	×	✓	×	✓	×	×	2
Ice	✓	✓	×	✓	✓	✓	5
Thrift	×	×	✓	✓	×	×	2
ZeroMQ	✓	✓	✓	✓	✓	✓	6
YAMI4	✓	✓	✓	×	✓	×	4
RTI	×	✓	×	✓	×	✓	3
Qpid	×	✓	×	×	✓	✓	3

Figure 3: Summary of evaluated middleware products.

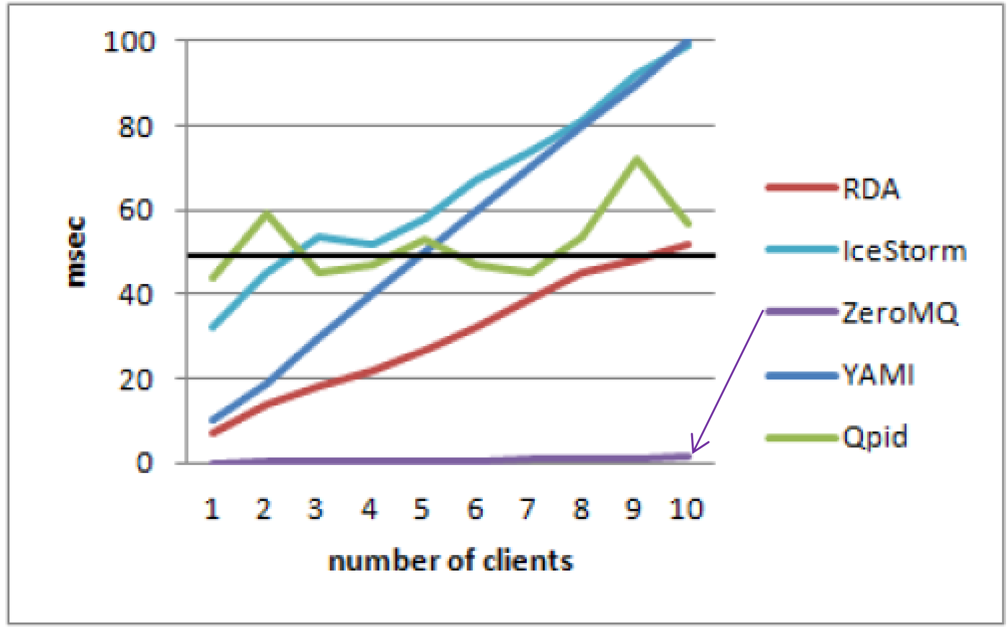
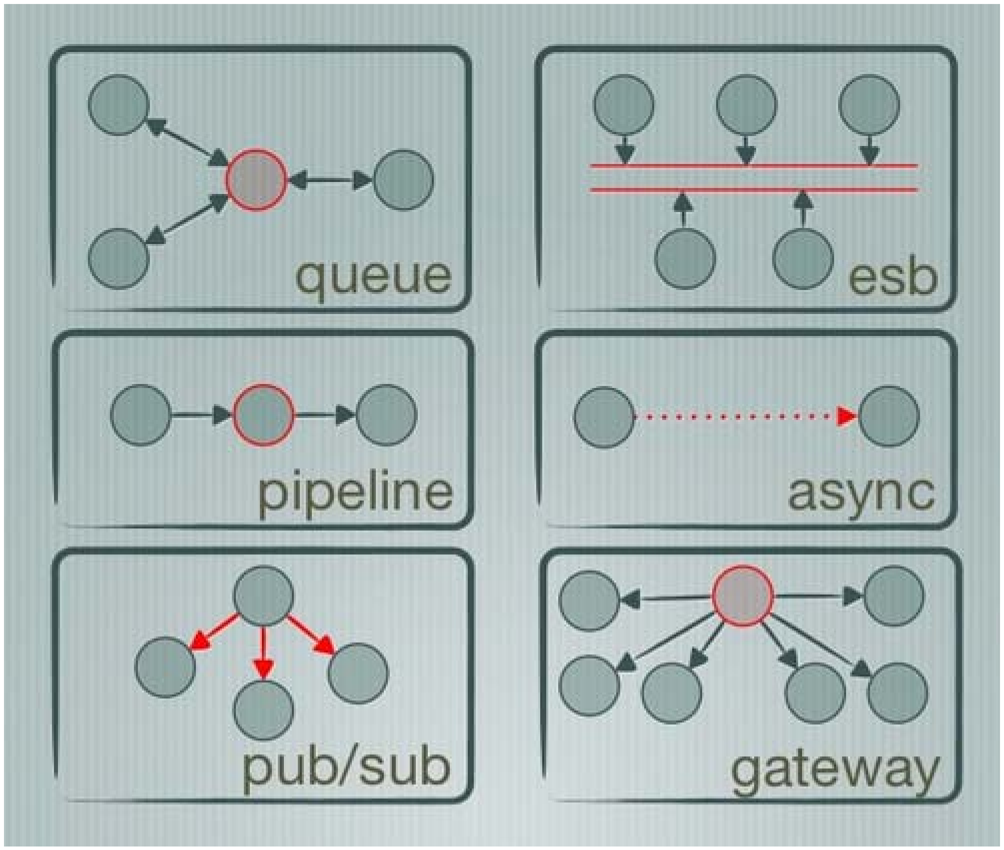


Figure 2: Test 3, pub-sub to a C++ server.

* A. Dworak, F. Ehm, W. Sliwinski, M. Sobczak, CERN, Geneva, Switzerland, 2011

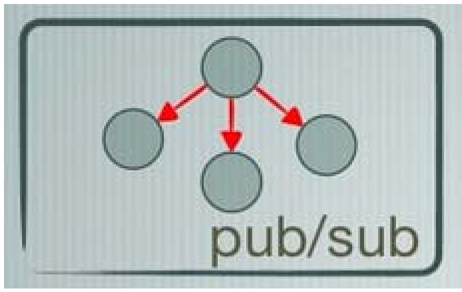
Message Patterns

PUB / SUB



ROUTER / DEALER

The Coding Pattern



Sub

wuclient.py

```python
#
#   Weather update client
#   Connects SUB socket to tcp://localhost:5556
#   Collects weather updates and finds avg temp in zipcode
#

import sys
import zmq

#  Socket to talk to server
context = zmq.Context()
socket = context.socket(zmq.SUB)

print "Collecting updates from weather server..."
socket.connect ("tcp://localhost:5556")

# Subscribe to zipcode, default is NYC, 10001
filter = sys.argv[1] if len(sys.argv) > 1 else "10001"
socket.setsockopt(zmq.SUBSCRIBE, filter)

# Process 5 updates
total_temp = 0
for update_nbr in range (5):
    string = socket.recv()
    zipcode, temperature, relhumidity = string.split()
    total_temp += int(temperature)

print "Average temperature for zipcode '%s' was %dF" % (
      filter, total_temp / update_nbr)
```

Pub

```python
#
#   Weather update server
#   Binds PUB socket to tcp://*:5556
#   Publishes random weather updates
#

import zmq
import random

context = zmq.Context()
socket = context.socket(zmq.PUB)
socket.bind("tcp://*:5556")

while True:
    zipcode = random.randrange(1,100000)
    temperature = random.randrange(1,215) - 80
    relhumidity = random.randrange(1,50) + 10

    socket.send("%d %d %d" % (zipcode, temperature, relhumidity))
```

GSF ZeroMQ Implementation

- Implemented the ROUTER – DEALER ZeroMQ pattern as a standard client / server streaming data transfer implementation.
- Allows for all support ZeroMQ transport protocols
  - TCP
  - In-Process (e.g., named pipes)
  - Pragmatic General Multicast (PGM)
  - Encapsulated PGM

ZeroMQ Example Code (from GSF)

Setup ZeroMQ:

```
m_zeroMQServer = new ZSocket(ZContext.Create(), ZSocketType.ROUTER);
m_zeroMQServer.Identity = ServerID.ToByteArray();
m_zeroMQServer.SendHighWatermark = m_maxSendQueueSize;
m_zeroMQServer.ReceiveHighWatermark = m_maxReceiveQueueSize;
m_zeroMQServer.Immediate = true;
m_zeroMQServer.SetOption(ZSocketOption.LINGER, 0);
m_zeroMQServer.SetOption(ZSocketOption.SNDTIMEO, 1000);
m_zeroMQServer.SetOption(ZSocketOption.RCVTIMEO, -1);
m_zeroMQServer.SetOption(ZSocketOption.RECONNECT_IVL, -1);
m_zeroMQServer.IPv6 = (Transport.GetDefaultIPStack() == IPStack.IPv6);
m_zeroMQServer.Bind(m_configData["server"]);
```

Route data to client:

```
// Lookup client info, adding it if it doesn't exist
TransportProvider<DateTime> clientInfo = GetClient(clientID);

// Router socket should provide identity, delimiter and data payload frames
using (ZMessage message = new ZMessage())
{
    // Add identity, delimiter and data payload frames
    message.Add(new ZFrame(clientID.ToByteArray()));
    message.Add(new ZFrame());
    message.Add(new ZFrame(data, offset, length));

    // ZeroMQ send is asynchronous, but API call is not thread-safe
    lock (m_sendLock)
        m_zeroMQServer.Send(message);
}
```

ZeroMQ Observations

- Excellent for distribution of simple messages
- Also supports stateful-style message protocol operations, but can require extra work
- Patterns and classes exist to make multi-threading with ZeroMQ simple, but API itself is not thread-safe
- Security, called CURVE, is now baked-in and is easy to "turn on"
- Low-level library is surprisingly fast and can have performance benefits over other socket implementations on IoT style hardware.

ZeroMQ Threading Patterns

- Calls into the ZeroMQ API library are not inherently thread-safe
- ZeroMQ uses patterns for simplifying multithreading

ØMQ for Multithreading

Don't use locks, semaphores, mutexes

Design app as message-driven tasks

Each task reads from 1..n sockets

Tasks can talk over inproc://

Tasks can be split into processes over tcp://

No wait states, no locks, full CPU use

Scalable to any number of cores

Thanks !