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PSI

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Experiences with ØMQ

BrightnESS meeting, Lund

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What ØMQ is

Message library primary mean to scale that acts as concurrency framework

From the point of view off networking:

- broker free
- various transport process: in-process, inter-process,TCP, multicast
- N-to-N connections
- different socket pattern: pub-sub, request-reply,…
- asynchronous I/O

From the point of view of programming:

- many languages supported: C, C++, C#, Python, Java, Tcl (Clojure, Delphi, Erlang, Go, Haskell, Lisp, Obj-C, PHP, Ruby,…)
- open source
- fast to learn, fast to use
- huge online documentation

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ØMQ features

- Messages are blobs of 0 to N bytes
- No difference between text (attention!) and raw data
- Messages can consist of multiple parts
- Message queues at sender and receiver
- One socket can connect to many socket: receiver can filter messages
- Automatic TCP reconnect (I will discuss with SINQhm)
- Zero copy for large messages (increase performances)

```
import zmq

# step 1: create context
context = zmq.Context()

#step 2: create socket & connect
socket = context.socket(zmq.PUB)
socket.bind("tcp://*:5557")

#step 3: send
msg = "Hello"
socket.send(msg)
```

```
import zmq

# step 1: create context
context = zmq.Context()

#step 2: create socket & connect
socket = context.socket(zmq.SUB)
socket.connect("tcp://127.0.0.1:5557")

#step3: receive
msg = socket.recv()
```

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```
# nonblocking send & recv
socket.send(msg,flag=NOBLOCK)
socket.recv(msg,flag=NOBLOCK)

# multipart message
socket.send(msg0,flag=SNDMORE)
socket.send(msg1)

while more:
    msg.append(socket.recv())
    more = socket.getsockopt(zmq.RCVMORE)
```

```
# limit number of messages that can be buffered
socket.setsockopt(zmq.HWM, 1000)

# set a filter for incoming messages
topicfilter = "10001"
socket.setsockopt(zmq.SUBSCRIBE, topicfilter)

# set a timeout for the receiver
socket.setsockopt(zmq.RCVTIMEO, timeout)

# do not copy message in local buffer
socket.send(msg,copy=False)
socket.recv(msg,copy=False)
```

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Basic message patterns

ØMQ provides sockets which enables advantage of message patterns

- PAIR
- PUSH - PULL
- REQ - REP
- PUB - SUB

Each pattern defines constrain on the network topology

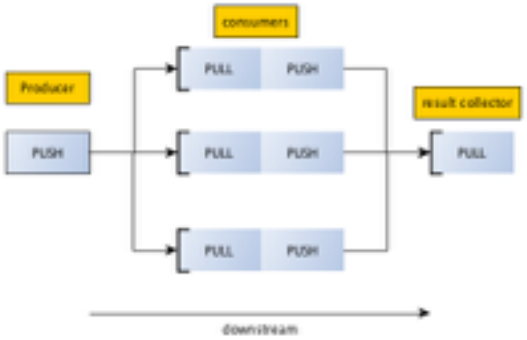
Failures

- Server dies
- With many connect/disconnect applications can leak memory and get slower
- Is network silence “good” or “bad”?
- If TCP connection stays silent for a while, network can disconnect

Techniques for reliability

PUSH-PULL

- Distribute messages between multiple workers in a pipeline
- One directional connection
- Round-robin distributor



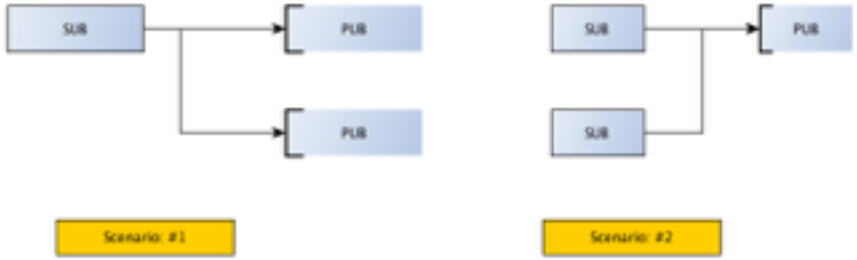
- Producer and collector stable part of architecture, consumers dynamic part

Possible issues

- If one consumer connects faster will receive more messages
- Large tasks requiring time to complete can cause unbalance
- If a consumer dies (while working) producer doesn’t know

PUB-SUB

- Addresses the “group messaging” problem
- Aimed for scalability: large volumes data sent rapidly to many recipients
- One-directional communications: no possibility to coordinate senders and receivers



- Messages are distributed without the knowledge of what or if any subscriber exist: a publisher with no connected subscribers drops the packages
- Filtering happens at the subscriber side

Possible issues

- Subs join late or drop off: messages are lost
- Subs slow fetching messages: queues overflow, pubs crash
- Network become overloaded and drop data

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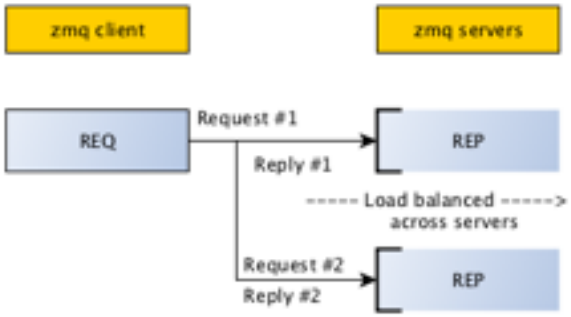
REQ-REP

- Distribute messages between multiple workers
- Client-server model
- Synchronous request-reply dialog



Possible issues

- Server dies: client hangs forever
- Network loses request or reply: client hangs forever

PAIR

- 1-to-1 bidirectional connection
- No specific state stored within socket
- Sever listen (bind) on a certain port and client connects to it

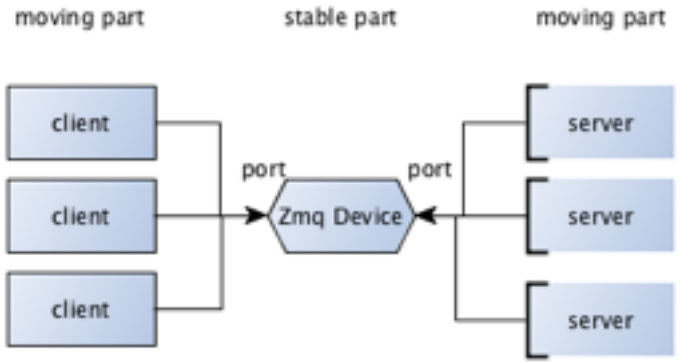
Multithreading & multiprocessing

- Design as message-driven application
- No need of locks and semaphores
- Transport: inproc:// , tcp://

0MQ devices

If both ends are dynamic it is not a good idea to provide well known ports.

ØMQ provides forwarding devices that became the stable point other components connect to



- QUEUE: forwarding device for request/reply communications
- FORWARDER: forwarding device for pub/sub communications
- STREAMER: streamer device for pipelined parallel communications

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Conclusion

ØMQ provides a communication library with turns out to be fast and reliable:

- the main communication patterns are already defined
- “devices” are in principle not required but can be useful, depending on the network structure.
- can handle different communication protocols and languages
- interoperable within different languages

Yes, it has some drawbacks:

- it provides only the communication layer, we have to build everything else on our own
- doesn’t provide serialisation
- requires developers take care of possible failures

Setup and results

- We are exploring different streaming solutions 0MQ, EPICS and shared memory
- Original data can be multiplied in order to reach ESS-like throughput
- 0MQ and EPICS: behaviour increasing message size / # clients