

## Programming Project 2

This is the second programming project using the JGroups toolkit (see Programming Project 1 and its README file for basic instructions; more instructions are also given in the class).

### 1 FIFO Order

Design and implement a protocol module FIFOORDER that orders its payload using FIFO order per sender according to the algorithm in the handout.

### 2 Causal Order

Design and implement a protocol module CAUSALORDER that implements a causal order among the broadcast messages. Use the simple algorithm from the handout that relies on FIFO-order reliable broadcast below (Algorithm 17 in Chapter 5).

If you are ambitious, design an algorithm for causal order relying on a vector clock and implement that.

### Implementation Notes

Start your implementation from modifying protocol DELAY, whose source is in `./src/org/jgroups/protocols/DELAY.java`.

To integrate your FIFO protocol module in the system, store it in `./src/org/jgroups/protocols/FIFOORDER.java` and compile the toolkit with `./jbuild.sh jar`. Make sure to enable your FIFO protocol in the protocol stack.

You can test the implementation as follows:

1. Obtain the stack `udp2.xml` from <http://www.zurich.ibm.com/~cca/sft09/proj2/udp2.xml> and save it in directory `./conf/`. It enables a REORDER protocol layer.
2. Obtain the protocol module REORDER from <http://www.zurich.ibm.com/~cca/sft09/proj2/REORDER.java>; as for the FIFO protocol module, store it it under directory `./src/org/jgroups/protocols/`, and recompile the toolkit using the command `./build.sh jar`. The REORDER protocol delays and reorders messages randomly.

3. Obtain a modified Chatter program from <http://www.zurich.ibm.com/~cca/sft09/proj2/Chatter.java>, run multiple copies of it in automatic mode with stack `udp2.xml`, and observe how messages are ordered or not. For example:

```
./jgroups Chatter -user alice -props udp2.xml -auto 5 \  
-size 3 -verify_ts_order > /tmp/alice &  
./jgroups Chatter -user bob -props udp2.xml -auto 5 \  
-size 3 -verify_ts_order > /tmp/bob &  
./jgroups Chatter -user charlie -props udp2.xml -auto 5 \  
-size 3 -verify_ts_order > /tmp/charlie &
```

The flag `-verify_ts_order` turns on code to detect violations of per-sender FIFO order using the timestamps in the automatically generated messages.

Proceed in analogously for the CAUSALORDER protocol module.