ECEN 757 | Homework 3 (Ungraded)

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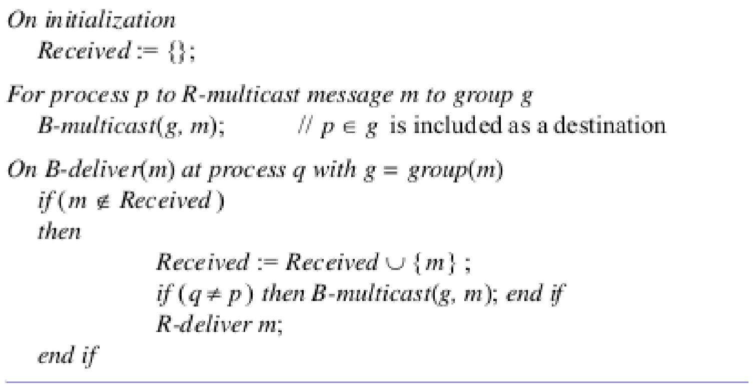
1 Explain why reversing the order of the lines ‘R-deliver m’ and ‘if (q$\neq$ p) then B- multicast(g, m); end if’ in Figure 15.9 makes the algorithm no longer satisfy uniform agreement. Does the reliable multicast algorithm based on IP multicast satisfy uniform agreement?

If the process delivers m to application layer before its’ multicast then the process q could potentially fail before it delivers the message breaking the uniform agreement.



```
On initialization
    Received := {};
For process p to R-multicast message m to group g
    B-multicast(g, m);          // $p \in g$ is included as a destination
On B-deliver(m) at process q with g = group(m)
    if (m ∉ Received)
    then
            Received := Received ∪ {m} ;
            if (q ≠ p) then B-multicast(g, m); end if
            R-deliver m;
    end if
```

Figure 1

2 Show that the FIFO-ordered multicast algorithm does not work for overlapping groups, by considering two messages sent from the same source to two overlapping groups, and considering a process in the intersection of those groups. Adapt the protocol to work for this case. Hint: processes should include with their messages the latest sequence numbers of messages sent to all groups.

By default the algorithm does not distinguish between groups in the messages that are multicast. So a process at the intersection could potentially receive two different messages with the same sequence id.

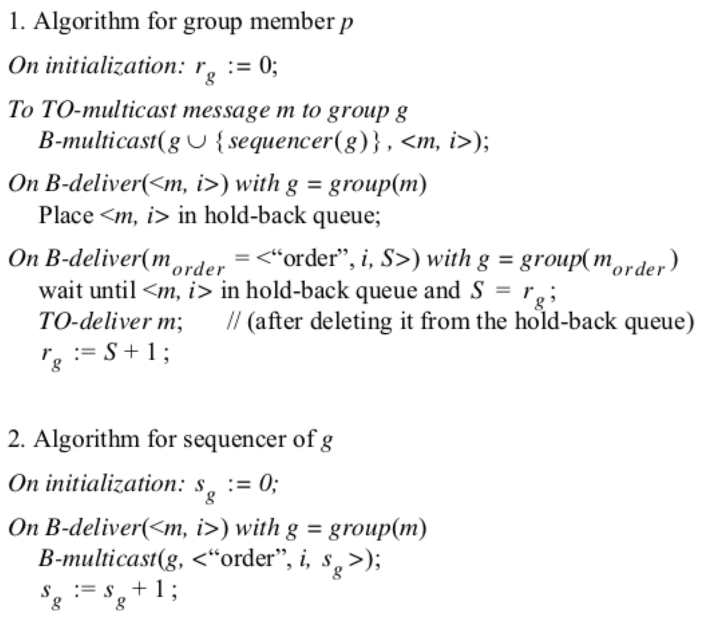
To resolve this the messages need to somehow identify which group they are coming from. A simple solution would be to include the entire vector that contains the greatest sequence number sent for each process from a group.

3 Show that, if the basic multicast that we use in the algorithm of Figure 15.13 is also FIFO-ordered, then the resultant totally-ordered multicast is also causally ordered. Is it the case that any multicast that is both FIFO-ordered and totally ordered is thereby causally ordered?

In the sequencer based totally-ordered multicast algorithm a central server keeps track of the global state of multicast messages via a global montonically increasing counter. This already guarantees the causality relationship between two different processes. For example, if p_1 wants to multicast a message and requests the sequence number from the server, and after multicasting that triggers / causes an event in p_2 that results in a multicast we know that the ordering of messages $m_1 \rightarrow m_2$ is going to satisfy the causality.

The only guarantee that does not exist here is the ordering of messages from the same machine. If we can guarantee that two messages from the same p_i follow the FIFO order then a totally-ordered multicast will satisfy the causality condition for that particular group.

A totally ordered and FIFO multicast algorithm does not always satisfy causality. Totally ordered only cares about all the machines receiving the messages in the same order but not necessarily in the order it received them. In this case we get causality because the sequencer algorithm respects the causality of the multicasting process.



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1. Algorithm for group member p

On initialization: $r_g$ := 0;

To TO-multicast message m to group g
    B-multicast($g \cup \{sequencer(g)\}$, <m, i>);

On B-deliver(<m, i>) with g = group(m)
    Place <m, i> in hold-back queue;

On B-deliver($m_{order}$ = <"order", i, S>) with g = group($m_{order}$)
    wait until <m, i> in hold-back queue and $S = r_g$;
    TO-deliver m;      // (after deleting it from the hold-back queue)
    $r_g$ := S + 1;


2. Algorithm for sequencer of g

On initialization: $s_g$ := 0;

On B-deliver(<m, i>) with g = group(m)
    B-multicast(g, <"order", i, $s_g$>);
    $s_g$ := $s_g$ + 1;
```

Figure 2

ordering

4 Consider the algorithm given in Figure 15.17 for consensus in a synchronous system, which uses the following integrity definition: if all processes, whether correct or not, proposed the same value, then any correct process in the decided state would chose that value. Now consider an application in which correct processes may propose different results, e.g., by running different algorithms to decide which action to take in a control system's operation. Suggest an appropriate modification to the integrity definition and thus to the algorithm.

We could use a majority rule meaning whichever process gets the more votes they win the election. If there is a tie, we can use the unique identifier of that process with a max function as the tie breaker.

5 Show that Byzantine agreement can be reached for three generals, with one of them faulty, if the generals digitally sign their messages.

Cryptographic signatures can be assumed to be unforgable and authentic. When a general sends an authentic message and the traitor sends / relays a forged message we can verify whether the message that is being relayed is authentic and from a general.