

```

1  |----- MODULE CSComm -----|
  | Specification of communication in a Client-Server system model.
5  | EXTENDS Naturals, Op
7  | CONSTANTS
8  |   Client,      the set of clients
9  |   Server       the (unique) server
11 | VARIABLES
12 |   cincoming,    cincoming[c]: incoming channel at the client c ∈ Client
13 |   sincoming     incoming channel at the Server
14 |-----|
15 | vars ≜ ⟨cincoming, sincoming⟩
16 |-----|
  | Messages between the Server and the Clients. There are two kinds of messages according to their
  | destinations. TODO: Abstraction from the concrete representation of messages.
22 | Msg ≜ [c : Client, ack : Nat, op : Op ∪ {Nop}] ∪ messages sent to the Server from a client c ∈ Client
23 |   [ack : Nat, op : Op ∪ {Nop}] messages broadcast to Clients from the Server
24 |-----|
25 | TypeOK ≜ ∧ cincoming ∈ [Client → Seq(Msg)]
26 |           ∧ sincoming ∈ Seq(Msg)
27 |-----|
  | The initial predicate.
31 | Init ≜ ∧ cincoming = [c ∈ Client ↦ ⟨⟩]
32 |           ∧ sincoming = ⟨⟩
33 |-----|
  | A client sends a message msg to the Server.
37 | CSend(msg) ≜
38 |   ∧ sincoming' = Append(sincoming, msg)
39 |   ∧ UNCHANGED cincoming
  | A client receives a message from the Server.
43 | CRev(c) ≜
44 |   ∧ cincoming[c] ≠ ⟨⟩ there are messages to handle with
45 |   ∧ cincoming' = [cincoming EXCEPT ![c] = Tail(@)] consume a message
46 |   ∧ UNCHANGED sincoming
47 |-----|
  | SRev and SSend below will be used together in one subaction. Therefore, there are no UNCHANGED
  | sub-formulas in their definitions.
  | The Server receives a message from some client c ∈ Client.
56 | SRev ≜
57 |   ∧ sincoming ≠ ⟨⟩ there are messages for the Server to handle with
58 |   ∧ sincoming' = Tail(sincoming) consume a message
  | The Server broadcasts messages to the Clients other than c ∈ Client. The “ack” parts of the
  | messages [ack : Nat, op : Op] broadcast are determined by the parameter “acks”.

```

```

65 SSend(c, acks, xop)  $\triangleq$ 
66    $\wedge$  cincoming' = [cl  $\in$  Client  $\mapsto$ 
67     IF cl = c
68       THEN cincoming[cl]
69       ELSE Append(cincoming[cl], [ack  $\mapsto$  acks[cl], op  $\mapsto$  xop])]
70 |-----|
    Properties of communication.
74 EmptyChannel  $\triangleq$  Init
75 |-----|
    \ * Modification History
    \ * Last modified Sat Jul 07 15:53:20 CST 2018 by hengxin
    \ * Created Sun Jun 24 10:25:34 CST 2018 by hengxin

```